NBER WORKING PAPER SERIES

EXCESS SAVINGS AND TWIN DEFICITS: THE TRANSMISSION OF FISCAL STIMULUS IN OPEN ECONOMIES

Rishabh Aggarwal
Adrien Auclert
Matthew Rognlie
Ludwig Straub

Working Paper 30185
http://www.nber.org/papers/w30185

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2022

This research is supported by the National Science Foundation grant numbers SES-1851717 and SES-2042691. We thank our discussants Oleg Itskhoki and Linda Tesar as well as Luigi Bocola, Larry Christiano, Marty Eichenbaum, Pierre-Olivier Gourinchas, Calvin He, Kilian Huber, Anders Humlum, Sebnem Kalemli-Ozcan, Greg Kaplan, Rohan Kekre, Thibaut Lamadon, Elisa Rubbo, Daan Struyven, and Christian Wolf for helpful comments. We thank Agustin Barboza for excellent research assistance. We thank Erica Deadman, Peter Ganong, Fiona Greig and Pascal Noel for sharing JPMorgan Chase Institute data. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Excess Savings and Twin Deficits: The Transmission of Fiscal Stimulus in Open Economies
Rishabh Aggarwal, Adrien Auclert, Matthew Rognlie, and Ludwig Straub
NBER Working Paper No. 30185
June 2022
JEL No. E21,E62,F32,F41

ABSTRACT

We study the effects of debt-financed fiscal transfers in a general equilibrium, heterogeneous-agent model of the world economy. In the long run, increases in government debt anywhere raise the world interest rate and increase private wealth everywhere. In the short run, a country with a larger-than-average fiscal deficit experiences both a large increase in private savings ("excess savings") and a small but persistent current account deficit (a slow-motion "twin deficit"). These patterns are consistent with the evolution of the world's balance of payments since the beginning of the Covid pandemic.

Rishabh Aggarwal
Stanford University
arishabh@stanford.edu

Adrien Auclert
Department of Economics
Stanford University
579 Jane Stanford Way
Stanford, CA 94305
and NBER
aauclert@stanford.edu

Matthew Rognlie
Department of Economics
Northwestern University
2211 Campus Drive
Evanston, IL 60208
and NBER
matthew.rognlie@northwestern.edu

Ludwig Straub
Department of Economics
Harvard University
Littauer 211
Cambridge, MA 02139
and NBER
ludwigstraub@fas.harvard.edu

1 Introduction

Governments around the world responded to the economic fallout from the Covid pandemic with unprecedented transfers to households and firms, financing these transfers with large fiscal deficits that will have a long-lasting effect on public debt levels.[1] During this period, private saving rates rose everywhere, and there were important movements in current accounts, including a notable increase in the U.S. current account deficit (see figure 1). In this paper, we ask: to what extent were these changes related? How do fiscal deficits affect the world's balance of payments in the short and the long run?

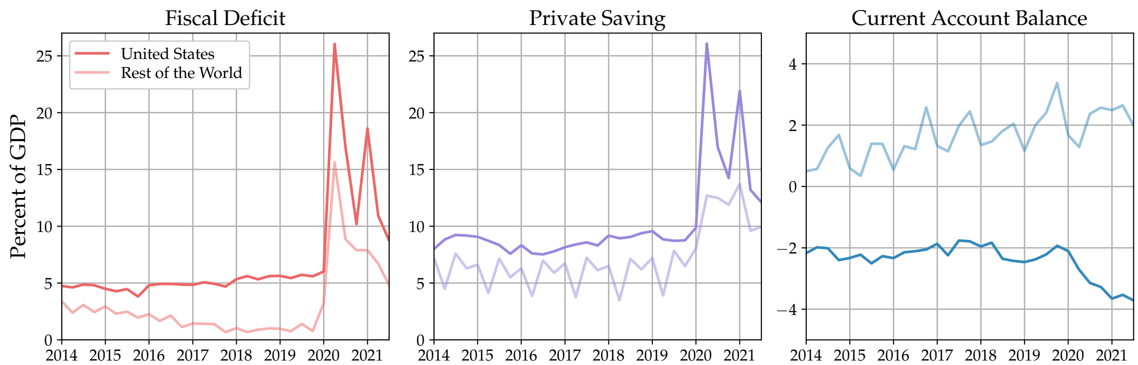
The standard Ricardian paradigm asserts that deficit-financed transfers raise private savings, with no effect on the current account or any other macroeconomic outcome. According to this view, households should save all of their transfers. This, however, is inconsistent with the substantial marginal propensities to consume (MPCs) out of transfers documented during the pandemic.[2] Moreover, even among households who initially saved their transfers, there is increasing evidence of a "spending down" phenomenon. For instance, figure 2 shows that, in the United States, middle class households—as proxied by the bottom 80% of the distribution of checking account balances—rapidly depleted the excess balances they built from each of the three rounds of stimulus payments.[3] To date, however, the analysis of fiscal policy in the open economy has been largely limited to models that either satisfy Ricardian equivalence, or that feature no spending down of past savings.

In this paper, we revisit the effects of debt-financed fiscal transfers in a model of the world economy that is consistent with both high MPCs and a spending down effect. We show that incorporating these features of the micro data dramatically changes the standard view of the effects of fiscal deficits on the balance of payments. In the long run, increases in government debt anywhere increase private wealth everywhere. In the short run, a country with a larger-than-average fiscal deficit experiences both a large increase in private savings ("excess savings") and a small but persistent current account deficit (a slow-motion "twin deficit"). These predictions are qualitatively consistent with the patterns in figure 1: the U.S. runs a large fiscal deficit relative to the rest of the world, has a larger-than-average increase in private savings, and a small, delayed deterioration in

[1] Congressional Budget Office (2020) and IMF Fiscal Affairs Department (2021) show that fiscal deficits were largely used to finance furlough pay, extended unemployment insurance benefits, stimulus checks, and so on. Projections in IMF (2021) imply a permanent effect of these deficits on levels of debt/GDP.

[2] Coibion, Gorodnichenko and Weber (2020), Ganong, Greig, Liebeskind, Noel, Sullivan and Vavra (2021) and Parker, Schild, Erhard and Johnson (2022) study MPCs from pandemic stimulus checks.

[3] See also New York Times, "Americans' Pandemic-Era 'Excess Savings' Are Dwindling for Many", December 7, 2021.



Note: For this graph, "Rest of the World" consists of 16 advanced economies, as listed in appendix table 4. Sources: U.S. National Income and Product Accounts, IMF International Financial Statistics, and OECD Quarterly Sector Accounts.

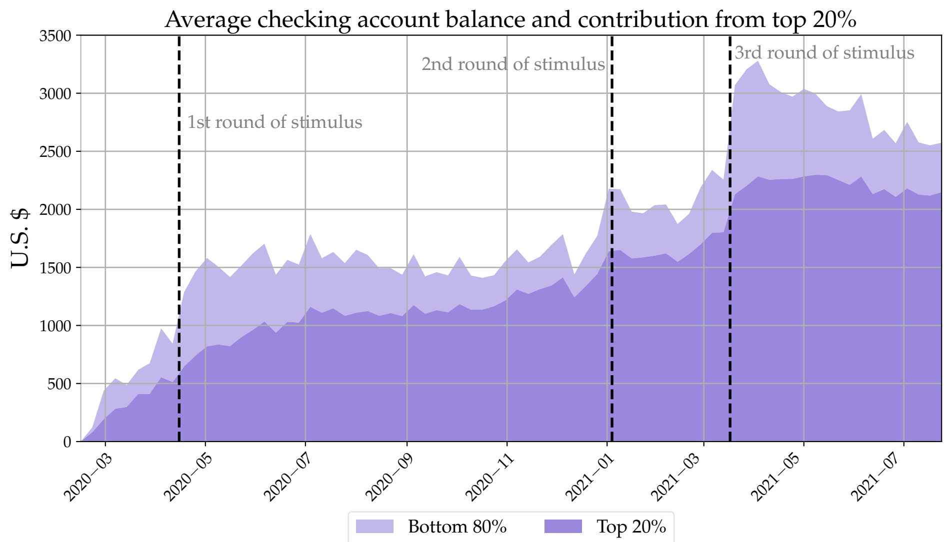
Figure 1: Recent developments in the world's balance of payments

its current account. We show that our model is in fact *quantitatively* consistent with the cross-country relationship between fiscal deficits, private savings, and current accounts observed since the beginning of the pandemic. We further show that our model's distributional dynamics are consistent with those of figure 2: in both model and data, a few quarters after a fiscal transfer, most of the excess savings are held by the rich.

Our model is a merger of two heterogeneous-agent models from previous work: the closed-economy fiscal policy model in Auclert, Rognlie and Straub (2018), and the open-economy model in Auclert, Rognlie, Souchier and Straub (2021c). It has three key features. First, households have buffer-stock behavior: in response to a fiscal transfer that raises their wealth above target, they try to spend down the additional wealth over time. This leads to large MPCs and a spending down effect, as in the data. Second, the model has open economies with substantial home bias in spending, also in line with the data. Third, going beyond the Galí and Monacelli (2005) small-open-economy assumption adopted in our earlier work, domestic fiscal policy affects the worldwide demand for goods as well as the world interest rate, as in Frenkel and Razin (1986).

We use this model to study the consequences of a worldwide increase in fiscal transfers financed by a permanent increase in countries' debt levels. Our model formalizes the following mechanism. When households in one country receive transfers, they spend out of those transfers according to their marginal propensities to consume, and initially save the rest, driving up private savings. Most of their spending is on domestic goods, which they earn back as income, further boosting private savings—but these savings pile up disproportionately among the rich, who earn income but have low MPCs.

The rest of household spending is on imported goods, leading to an increase in aggregate imports. But because the same phenomenon also happens in other countries,



Note: This graph, courtesy of the JPMorgan Chase Institute, shows the average checking account balance relative to the first week of 2020, and the contributions to this mean from the top 20% and the bottom 80% of the distribution of balances. These contributions are estimated from information about the 25, 50, 75 and 90th percentiles by fitting a spline through the cumulative distribution function. These percentiles are reported here. We thank Erica Deadman, Peter Ganong, Fiona Greig and Pascal Noel for sharing the data.

Figure 2: Increase in mean checking account balance and contribution from the top 20%

aggregate exports increase as well. On balance, countries that give larger-than-average transfers run current account deficits, and other countries run current account surpluses. In either case, the share of spending on foreign goods is small everywhere, and so the initial magnitude of the change in current accounts is also small. This implies that, initially, each country finances its own fiscal deficit through a similar increase in private savings.

The model's dynamics, however, do not stop when the transfers end. Instead, households keep spending out of their initial excess savings. Some fraction of this later spending goes into imports and exports, too, prolonging the current account patterns. In other words, the spending down phenomenon implies that the effects of fiscal deficits on current accounts are very persistent: twin deficits happen in slow motion.

In the paper, after setting up the model in section 2, we formalize this mechanism in two parts. First, in section 3, we analytically characterize the effects of fiscal deficits in a small economy within our world economy model. There, assuming a world interest rate of $r = 0$, we prove a stark result: in the long-run natural allocation, private wealth is unchanged, so any new debt issued by the government must be entirely held abroad. In other words, eventually, fiscal deficits translate one-for one-into current account deficits. In the short-run, however, private savings absorb the vast majority of the initial transfer. The speed of convergence is dictated by the degree of openness α and the matrix $\mathbf{M}$ of "intertemporal MPCs" (Auclert et al. 2018), formalizing the role of home bias and the spending down effect for the transmission of fiscal deficits.

Then, in section 4, we show that the outcomes of symmetric countries in a worldwide fiscal expansion can be decomposed into two parts: a) aggregate worldwide outcomes, given by treating the world as a closed economy running the world average fiscal deficit, and b) relative cross-country outcomes, given by treating each country as if it was a small economy faced with its deficits *net* of the world average. Part a) implies that increases in government debt anywhere raise the world interest rate and increase private wealth everywhere. Part b), combined with our small economy results, implies that large-deficit countries run slow-motion twin deficits, and that eventually any debt issuance they have in excess of the world average is held abroad. It also implies that, after a one-off fiscal expansion in all countries, a cross-country regression of cumulative private savings on cumulative fiscal deficits delivers a coefficient that starts around 1 and decays towards 0 over time, and a cross-country regression of cumulative current accounts on cumulative fiscal deficits delivers a coefficient that starts around 0 and decays towards -1 over time.

In section 5, we test this prediction of our model using recent data on the world's balance of payments. We construct measures of cumulative private savings, current accounts and fiscal deficits since 2020Q1. After 5 quarters, the regression coefficients on fiscal deficits are 0.79 for private savings and -0.34 for current accounts, compared to our baseline model's predictions of 0.81 and -0.19, respectively. We discuss potential confounders from non-fiscal shocks over this period, including the concern that fiscal policy may be correlated with the severity of the pandemic across countries. We find that the resulting bias to our empirical estimates is likely to be modest, because variables that directly measure the severity of the pandemic in each country have limited association with excess savings or current accounts in the data. We show that this is consistent with theory: in general equilibrium, a Covid shock that does not involve a fiscal deficit cannot increase aggregate savings very much, and may in fact lower savings.

Finally, in section 6, we turn to a quantitative version of our model that addresses the main limitations of our prior analysis. First, we relax the symmetry assumption, calibrating to data on openness and fiscal policy for 26 countries. Second, we relax the assumption that the fiscal policy shock was a one-off shock in 2020Q1, instead feeding in the realized time path of fiscal deficits since that date. Finally, and most importantly, we explicitly add a Covid shock to each country, inferring the magnitude of this shock from the realized levels of consumption worldwide, similar to the procedure in Gourinchas, Kalemli-Özcan, Penciakova and Sander (2021). Simulating the effect of both the fiscal and the Covid shocks,[4] we find that the model still replicates the cross-country fis-

[4]This step is technically challenging because we solve a world economy model keeping track of 26 wealth distributions, but we show how to adapt the sequence-space Jacobian method (Auclert, Bardóczy,

cal pass-through coefficients documented in our empirical section very well. In addition, we show that fiscal deficit shocks explain the vast majority of the observed level of excess savings, with the Covid shock playing essentially no role. By contrast, and consistent with a slow-motion twin deficit effect, there is a role for other shocks in explaining current accounts, at least over the short horizon we study.

Our paper refines the original twin deficit hypothesis, according to which fiscal deficits cause (contemporaneous) current account deficits. This hypothesis was popular in the 1980s, when the Reagan tax cuts were followed by a large dollar appreciation and increase in the current account deficit, consistent with the predictions of the Mundell-Fleming model (e.g. Feldstein 1993, Ball and Mankiw 1995). It then fell out of fashion in the 1990s and 2000s, since the Clinton years featured both a fiscal surplus and a current account deficit—a so-called "twin divergence". Empirically, Bernheim (1988), Chinn and Prasad (2003), and Chinn and Ito (2007) find a generally positive correlation between fiscal deficits and current account deficits in a panel of countries, but it is well understood that the data is driven by many shocks beyond fiscal policy.[5] More recent work using identified tax shocks has reached mixed conclusions: using a structural VAR, Kim and Roubini (2008) find evidence for "twin divergence", while, using narratively-identified tax shocks, Feyrer and Shambaugh (2012) and Guajardo, Leigh and Pescatori (2014) find evidence for the causal twin deficit hypothesis. Our *slow-motion twin deficit* result can help interpret these findings: it suggests that a causal twin deficit relationship may not be detectable over the short run, where it can be swamped by other shocks in the data, but that it should start to appear as one considers longer horizons.

As mentioned at the top of the paper, the usual open-economy analysis of fiscal policy is conducted in models featuring Ricardian equivalence. In this context, twin deficits emerge only when governments finance government spending, not transfers (e.g. Corsetti and Müller 2006). Models with hand-to-mouth agents a la Galí, López-Salido and Vallés (2007), Bilbiie (2008), Farhi and Werning (2016), and House, Proebsting and Tesar (2020) imply some twin deficits, but, as explained in Bilbiie, Eggertsson and Primiceri (2021), these occur only contemporaneously with the fiscal deficit, with excess savings sticking around forever after that: in these models, there is no spending down of past savings. Our model, by contrast, predicts a prolonged effect of fiscal deficits on current accounts.

The finite-horizon Blanchard (1985) model and its descendants (e.g. Ghironi 2006 and Kumhof and Laxton 2013) behave more similarly to ours in the aggregate. Blanchard

Rognlie and Straub 2021a) to deal with this challenge.

[5] For instance, a business cycle boom typically is associated with a current account deficit as import demand rises, as well as a fiscal surplus due to higher tax revenue and reduced transfer payments.

(1985) pointed out that the net foreign asset position of a country deteriorated in response to a permanent increase in the public debt, and that this involved a transition to the new steady state, but he overstated the speed of this transition for two reasons. First, in his model there is no selection of the set of spenders at any point in time: households who have saved their transfers until today remain equally likely to spend them today. Second, and more importantly, he worked with a model with no home bias.

Finally, our paper contributes to the Heterogeneous-Agent New Keynesian literature. This literature has so far studied monetary policy in closed economies (McKay, Nakamura and Steinsson 2016, Kaplan, Moll and Violante 2018, Auclert 2019, Werning 2015), fiscal policy in closed economies (Oh and Reis 2012, McKay and Reis 2016, Auclert et al. 2018, Hagedorn, Manovskii and Mitman 2019) and monetary policy in open economies (Auclert et al. 2021c, Guo, Ottonello and Perez 2021).[6] To our knowledge, we are the first paper to study fiscal policy in open economies in this class of models, and also the first to write a many-country model of large open economies.

2 Model

We now describe our many-country HANK model. The general structure of the model is borrowed from Galí and Monacelli (2005)'s small open economy, representative-agent New Keynesian model. We add three elements to this model. First, as in Auclert et al. (2021c), in each country there are heterogeneous agents facing idiosyncratic income uncertainty and borrowing constraints. Second, as in Auclert et al. (2018)'s closed-economy model, agents are taxed according to a progressive tax schedule, and the government conducts fiscal policy by changing transfers, purchasing local goods, and issuing or retiring public debt. Finally, an innovation of this paper is to modify the Galí and Monacelli (2005) environment to consider an integrated world economy made of any number of countries, interacting in frictionless capital markets but subject to home bias in spending. Asset market clearing at the world level is essential to understand the implications of a worldwide fiscal expansion such as the one that motivates this paper.

We write down the model by assuming that individuals have perfect foresight over aggregate variables, and solve the model to first order in these aggregates. As Auclert et al. (2021a) show, this delivers the first-order perturbation solution of the equivalent model with aggregate shocks.

[6] See also de Ferra, Mitman and Romei (2020), Oskolkov (2021), and Zhou (2022).

World economy setup. There are K countries. Consumption c_{it}^k of consumer i in country $k = 1 \dots K$ aggregates a "home" good H, produced by country k itself, and a "world" good W, made up of goods produced by all countries. The elasticity of substitution between the home and the world good is η, with $1 - \alpha^k$ measuring the extent of home bias in consumption:

$$c_{it}^k = \left[\left(1 - \alpha^k\right)^{\frac{1}{\eta}} \left(c_{iHt}^k\right)^{\frac{\eta-1}{\eta}} + \left(\alpha^k\right)^{\frac{1}{\eta}} \left(c_{iWt}^k\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

The world good basket W is common to all countries and given by:

$$c_{iWt}^k = \left(\sum_{l=1}^K \left(\omega^l\right)^{\frac{1}{\gamma}} \left(c_{iWt}^{k,l}\right)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \tag{2}$$

where $c_{iWt}^{k,l}$ the consumption of world goods from country l by consumer i in country k.[7] We assume that $\gamma > 0$, $\eta > 0$, $\omega^l \geq 0$, and $\sum_{l=1}^K \omega^l = 1$. Note that the weights $\{\omega^l\}$ are the same in each country k.

Domestic agents. We now describe the domestic economy in any given country k. To simplify notation, we call that country "home" and drop the superscript k whenever there is no ambiguity. Home households have preferences over goods described by equation (1). They work hours N_t at disutility $v(N_t)$, but take these hours as given in the short run. A union occasionally resets their nominal wage W_t, denoted in home currency. Households invest in a mutual fund asset with nominal value A subject to a borrowing constraint, which we assume to be equal to zero for simplicity. This asset pays a real return r_t^p in terms of the consumer price index P_t, denoted in home currency. Households are also subject to a CPI-indexed tax schedule a la Heathcote, Storesletten and Violante (2017), with intercept ν_t and degree of progressivity λ. Their Bellman equation is therefore:

$$\begin{aligned} V_t(A, e) \quad &= \quad \max_{c_F, c_H, a'} u\left(c\left(c_H, c_W\right)\right) - v\left(N_t\right) + \beta \mathbb{E}_t\left[V_{t+1}\left(A', e'\right)\right] \\ \text{s.t.} \quad & P_{Ht} c_H + \sum_{l=1}^K P_{lt} c_W^l + A' = \left(1 + r_t^p\right) \frac{P_t}{P_{t-1}} A + P_t \cdot \nu_t \left(e \frac{W_t}{P_t} N_t\right)^{1-\lambda} \\ & A' \geq 0 \end{aligned} \tag{3}$$

[7] Note that consumers from country k value two types of goods from their own country: the home good c_{iHt}^k and the world good $c_{iWt}^{k,k}$.

where $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, with $c(c_H, c_W)$ described in (1), and $v(n) = \varphi \frac{n^{1+\phi}}{1+\phi}$. We define aggregate real post-tax income as the cross-sectional average:

$$Z_t \equiv \mathbb{E}_e \left[\nu_t \left(e \frac{W_t}{P_t} N_t \right)^{1-\lambda} \right]$$

Since labor is not a choice, Z_t is taken as given by the household. Defining $a = \frac{A}{P_{t-1}}$ as the real value of household assets, and using standard two-step budgeting arguments with CES utility, we can solve for policy functions as follows. First, rewrite equation (3) as:

$$\begin{aligned} V_t(a,e) &= \max_{c,a'} u(c) + \beta \mathbb{E}_t \left[V_{t+1}(a', e') \right] \\ \text{s.t.} \quad & c + a' = \left(1 + r_t^p\right) a + \frac{e^{1-\lambda}}{\mathbb{E}\left[e^{1-\lambda}\right]} Z_t \\ & a' \geq 0 \end{aligned} \tag{4}$$

The solution to this problem gives households' optimal choice of consumption vs. savings for given aggregate sequences $\left\{r_t^p, Z_t\right\}$. Denote by $c = c_t(a,e)$ the resulting consumption policy. Then, the demand for home goods (respectively, for country l goods) for a household in state (a,e) is given by:

$$c_{Ht}(a,e) = (1-\alpha) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} c(a,e) \qquad c_{Wt}^l(a,e) = \alpha \omega^l \left(\frac{P_{lt}}{P_{Wt}} \right)^{-\gamma} \left(\frac{P_{Wt}}{P_t} \right)^{-\eta} c(a,e)$$

where $P_t = \left[(1-\alpha)(P_{Ht})^{1-\eta} + \alpha (P_{Wt})^{1-\eta} \right]^{\frac{1}{1-\eta}}$ is the consumer price index and $P_{Wt} = \left[\sum_{l=1}^K \omega^l (P_{lt})^{1-\gamma} \right]^{\frac{1}{1-\gamma}}$ the price of the world good, both expressed in home currency. Aggregating up, and writing C_t for the aggregate consumption policy across the distribution of agents, total domestic demand for home goods and for country l goods is given by:

$$C_{Ht} = (1-\alpha) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} C_t \tag{5}$$

$$C_{Wt}^l = \alpha \omega^l \left(\frac{P_{lt}}{P_{Wt}} \right)^{-\gamma} \left(\frac{P_{Wt}}{P_t} \right)^{-\eta} C_t \tag{6}$$

Production and prices. Firms in the home economy produce using a linear production function with productivity Θ that is country-specific, but constant over time (ie $\Theta_t^k = \Theta^k$

for each k, generating level differences across countries):

$$Y_t = \Theta N_t \tag{7}$$

They have flexible prices and there is perfect competition in the goods market. This implies that the home currency price of home goods is:

$$P_{Ht} = \frac{W_t}{\Theta} = \frac{w_t P_t}{\Theta} \tag{8}$$

where $w_t \equiv \frac{W_t}{P_t}$ denotes the real wage. Firms make zero profits. A standard derivation of the New Keynesian wage Phillips curve (e.g. Auclert et al. 2018) implies that wage inflation, $\pi_{wt} = \frac{W_t}{W_{t-1}} - 1$, is given by:

$$\pi_{wt} = \kappa_w \left(\frac{v'(N_t) N_t}{\frac{\epsilon_w}{\epsilon_w - 1} (1-\lambda) Z_t u'(C_t)} - 1 \right) + \beta \pi_{wt+1} \tag{9}$$

where ϵ_w is the elasticity of substitution between unions in labor demand and λ is the progressivity of taxes (taxes are distortionary for labor supply when $\lambda > 0$). Since, from (8), $\frac{P_{Ht+1}}{P_{Ht}} = \frac{W_{t+1}}{W_t}$, producer price inflation is equal to wage inflation at all times,

$$\pi_{Ht} = \pi_{wt} \tag{10}$$

We assume that there is is frictionless trade for each individual good, so that the law of one price holds everywhere.[8]

Since the world good is identical in all countries, it acts as a natural world numeraire. To implement this numeraire in a consistent and intuitive way, we introduce an infinitesimal reference country, the "star country", whose monetary policy is set to keep the price of the numeraire world good in its currency, the "star currency", always equal to 1. We further assume that the "CPI" in the star country consists entirely of world goods. By assumption, then, $P^*_{Wt} = P^*_t = 1$. We then let $\mathcal{E}_t$ be the nominal exchange rate relative to the star currency—the number of domestic currency units per units of star currency—such that an increase in $\mathcal{E}_t$ represents a depreciation of the currency relative to the star currency. The star currency is then a useful unit of account for exchange rates: the bilateral exchange rate between any two countries k and l is given by $\mathcal{E}^k_t / \mathcal{E}^l_t$.

The law of one price implies that, in each country k, the price of good l is equal to

[8] It would be interesting to extend this setting to allow for imperfect pass-through, such as in a local or dollar currency pricing paradigm (Devereux and Engel 2003, Gopinath, Boz, Casas, Díez, Gourinchas and Plagborg-Møller 2020, Gopinath and Itskhoki 2021).

country l's home good price once expressed in country k's currency, i.e. $P^k_{lt} = \frac{\mathcal{E}^k_t}{\mathcal{E}^l_t} P^l_{Ht}$. Since, in the star currency, $P^*_{Wt} = 1$, this implies in particular that, for the home economy (where, recall, we drop the country superscript k):

$$P_{Wt} = \mathcal{E}_t \tag{11}$$

that is, the price of world goods is equal to the exchange rate in the home currency. Finally, writing Q_t for the real exchange rate between the home and the star currency, we have:

$$Q_t = \frac{\mathcal{E}_t}{P_t} \tag{12}$$

To first order, CPI inflation is given by $\pi_t = (1-\alpha)\,\pi_{Ht} + \alpha\pi_{Wt}$. Combining this with (10), (11), and the definition of the price index, we obtain:

$$\pi_t = \pi_{wt} + \frac{\alpha}{1-\alpha}\left(q_t - q_{t-1}\right) \tag{13}$$

where $q_t = \log Q_t$ is the log of the real exchange rate. Equation (13) shows how real exchange rate depreciations pass through to CPI inflation, over and above domestic inflation.

Government. Fiscal policy sets exogenous paths for government debt B_t and spending G_t, which it spends entirely on local goods. It then levies taxes T_t by changing the slope ν_t of the retention function, with fixed progressivity λ, as in Auclert et al. (2018). Bonds are denominated in units of the domestic consumption bundle, and government spending and tax revenue are denominated in units of home goods. Bonds are short-term, and promise to pay at t the ex-ante real interest rate r_{t-1} that prevails between time $t-1$ and time t. The government budget constraint is then:

$$B_t = (1 + r_{t-1})\,B_{t-1} + \frac{P_{Ht}}{P_t}\left(G_t - T_t\right) \tag{14}$$

The government taxes labor income $w_t N_t$ and lets individuals retain Z_t in the aggregate, so that $\frac{P_{Ht}}{P_t} T_t = w_t N_t - Z_t$. Combining (7) and (8), aggregate pre-tax wage income is:

$$w_t N_t = \frac{P_{Ht}}{P_t}\Theta N_t = \frac{P_{Ht}}{P_t} Y_t \tag{15}$$

We therefore have the following relationship between post-tax income Z_t, output Y_t, and taxes T_t:

$$Z_t = \frac{P_{Ht}}{P_t}(Y_t - T_t) \tag{16}$$

Monetary policy sets the ex-ante real rate for $t \geq 0$. We consider three different rules. The first is a real interest rate rule,

$$r_t = r \tag{17}$$

We think of this rule as capturing the case of "no monetary response", since it holds fixed the vehicle of monetary transmission to the real economy, which is the domestic-CPI-based real interest rate. By contrast, a Taylor rule allows for a response of the real interest rate to local economic conditions captured by the aggregate inflation rate:

$$i_t = r^* + \phi_\pi \pi_t \tag{18}$$

The third rule we consider simply implements the path of "natural" interest rates, which ensures that there is no wage inflation at any time, ie $\pi_{wt} = \pi^n_{wt} = 0$,

$$r_t = r^n_t \tag{19}$$

This path corresponds to the flexible-wage limit of the model, in which unions can flexibly set wages.[9]

In our analysis below, we will at times consider the limit of a perfectly open economy, $\alpha \to 1$, that follows the constant-r monetary policy rule (17). We spell out this limit in appendix A.4, where we show that this is identical to a monetary policy that targets a constant path for the terms of trade $\frac{P_{Ht}}{P_{Wt}}$.[10]

World demand for home goods. Appendix A.1 shows that, combining each country's demand system with the law of one price, world demand for the home good is given by:

$$C^*_{Ht} = \omega \left(\frac{P_{Ht}}{P_{Wt}}\right)^{-\gamma} C^*_t \tag{20}$$

[9] This limit is close, but not identical, to the model in which all agents are *individually* on their labor supply curves at all times. The difference comes from the fact that (a) unions still have monopoly power, and (b) the relationship $\frac{v'(N_t)}{u'(C_t)} = \frac{\epsilon_w}{\epsilon_w - 1}(1-\lambda)\frac{Z_t}{N_t}$ holds in the aggregate but not for each individual.

[10] By contrast, in this limit the real exchange rate Q_t is outside of the control of monetary policy.

where C_t^* is world import demand, defined as:

$$C_t^* \equiv \sum_{l=1}^{K} \alpha^l \left(Q_t^l\right)^{-\eta} C_t^l \tag{21}$$

Asset pricing equations. The domestic mutual fund's assets consist of home real bonds B_t and star country bonds B_t^*. The latter pay a nominal interest rate of i_t^* in star currency. Since $P_{Wt}^* = 1$ at all times, i_t^* is also equal to the real interest rate in terms of the world goods bundle, which is common across all countries. At every point in time, the liquidation value of the mutual fund's liabilities equals the value of its assets, which implies:

$$\left(1 + r_t^p\right) A_{t-1} = \left(1 + r_{t-1}\right) B_t + \left(1 + i_{t-1}^*\right) Q_t B_t^*$$

Optimization implies that, for all $t \geq 0$, ex-ante CPI-based real interest rates across countries are related by the real uncovered interest rate parity (UIP) condition:

$$1 + r_t = \left(1 + i_t^*\right) \frac{Q_{t+1}}{Q_t} \tag{22}$$

as well as the domestic no-arbitrage condition $r_{t+1}^p = r_t$ for all $t \geq 0$. We further assume that gross foreign asset positions are zero initially, that is, $A_{ss} = B_{ss}$, implying $r_0^p = r_{ss} = r_{-1}$.[11] We therefore have:

$$r_t^p = r_{t-1} \quad \forall t \geq 0 \tag{23}$$

Finally, assuming that the mutual fund can also invest in zero-net-supply domestic nominal bonds, we obtain the nominal UIP equation, as well as the Fisher equation:

$$1 + i_t = \left(1 + i_t^*\right) \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{24}$$

$$1 + i_t = \frac{1 + r_t}{1 + \pi_{t+1}} \tag{25}$$

Equilibrium. We define equilibrium in two steps. First, we define an open-economy equilibrium for given world "star" interest rate and export demand $\{i_t^*, C_t^*\}$. Second, we define an integrated world equilibrium, in which $\{i_t^*, C_t^*\}$ are endogenously determined. Since a small open economy is too small to affect $\{i_t^*, C_t^*\}$, it can be analyzed as a open-economy equilibrium given these two aggregates. This formulation therefore provides a

[11] This would be different if the mutual fund invests in international assets/liabilities, there is an initial net foreign asset position, or government bonds are long-term. See Auclert et al. (2021c) for a model in which this is the case.

natural extension of the Galí and Monacelli (2005) model to an integrated world economy in which global asset and goods markets clear.

Definition 1. Given sequences for star currency monetary policy and world exports $\{i_t^*, C_t^*\}$, as well as paths for fiscal policy $\{G_t, B_t\}$, an **open-economy equilibrium** is a sequence of aggregates $\{Q_t, Y_t, C_t, A_t, T_t, Z_t, r_t\}$ as well as mutually consistent policy functions and distributions of individuals over their state variables (a, e), such that: a) the real interest rate parity condition (22) holds, b) the relative prices $\frac{P_{Ht}}{P_t}$ and $\frac{P_{Ht}}{P_{Wt}}$ are consistent with the real exchange rate Q_t and the pricing equation for world goods (11), c) taxes T_t ensure that (14) holds and real income Z_t by (16), d) household choices are optimal given $\{Z_t, r_t\}$, and their aggregation is given by $\{C_t, A_t\}$, e) domestic wage inflation and CPI inflation satisfy (9) and (13), f) r_t is consistent with the country's monetary policy rule, that is, one of (17), (18), or (19), and g) the domestic goods market clears:

$$Y_t = C_{Ht} + C_{Ht}^* + G_t \tag{26}$$

In an open-economy equilibrium, any excess of demand for assets domestically A_t relative to its supply B_t is held abroad in the form of a net foreign asset position, which we write as nfa_t:

$$A_t = B_t + \text{nfa}_t \tag{27}$$

The trade deficit of the economy is given by

$$TD_t \equiv C_t - \frac{P_{Ht}}{P_t}(Y_t - G_t) \tag{28}$$

Appendix A.2 shows that, in equilibrium, the trade deficit is related to the current account CA_t (the change in the net foreign asset position) via the standard balance of payments identity:

$$CA_t \equiv \text{nfa}_t - \text{nfa}_{t-1} = r_{t-1}\text{nfa}_{t-1} - TD_t \tag{29}$$

Because we ruled out initial gross positions, there are no valuation effects in (29).

We now turn to the world economy. In it, C_t^* and i_t^* are endogenously determined, as per the following definition.

Definition 2. A **world economy equilibrium** given country-specific productivity level Θ^k, preference parameters $\{\alpha^k, \omega^k, \beta^k\}$, income processes e_t^k, monetary policy rules, and fiscal policy paths $\{G_t^k, B_t^k\}$, is a set of world variables $\{i_t^*, C_t^*\}$ and country-specific aggregates $\{Q_t^k, Y_t^k, C_t^k, A_t^k, T_t^k, Z_t^k, r_t^k\}$ such that, in each country, $\{Q_t^k, Y_t^k, C_t^k, A_t^k, T_t^k, Z_t^k, r_t^k\}$

is an open-economy equilibrium given country-specific parameters and $\{i_t^*, C_t^*\}$, world export demand equals world import demand:

$$C_t^* = \sum_{k=1}^{K} \alpha^k \left(Q_t^k\right)^{-\eta} C_t^k \tag{30}$$

and the price of world goods in the star currency P_{Wt}^* is constant and equal to 1,

$$\sum_{k=1}^{K} \omega^k \left(\frac{P_{Ht}^k}{\mathcal{E}_t^k}\right)^{1-\gamma} = 1 \tag{31}$$

In appendix A.3, we show that these conditions are equivalent to world asset market clearing, which reads:

$$\sum_k \frac{A_t^k}{Q_t^k} = \sum_k \frac{B_t^k}{Q_t^k} \tag{32}$$

or alternatively, by (27), the world's net foreign asset position is zero:

$$\sum_k \frac{\text{nfa}_t^k}{Q_t^k} = 0 \tag{33}$$

In a world economy equilibrium, the world goods market also clears, which reads:

$$\sum_k \frac{P_{Ht}^k}{\mathcal{E}_t^k} \left(Y_t^k - G_t^k\right) = \sum_k \frac{P_t^k C_t^k}{\mathcal{E}_t^k} \tag{34}$$

Calibration. We next calibrate the world economy equilibrium of our model. We use this calibration to analyze the open economy equilibrium of an individual small country in section 3, and the full world equilibrium in section 4.

We start from an initial steady state with no net foreign asset position in any country, $\text{nfa}^k = 0$, and where all relative prices are 1. In particular, $Q^k = \left(\frac{P_H}{P}\right)^k = 1$. (We omit the subscript "t" when discussing steady state values.) By equation (29), the trade deficit is zero in each country k, so imports and exports are equal, that is,

$$\alpha^k C^k = \omega^k C^* \tag{35}$$

where $C^* = \sum_{l=1}^{K} \alpha^l C^l$.

Our baseline calibration assumes that all countries are perfectly symmetric, except for size. (We relax this assumption in section 6.) That is, countries have identical preferences,

Parameter	r	σ	η	γ	α	ϕ	λ
Value	0	1	1	1	0.16	2	0.181
Parameter	G/Y	B/Y	nfa/Y	β	δ	κ_w	ϕ_π
Value	0.14	0.82	0	0.992	0.098	0.1	1.5

Table 1: Baseline calibration

openness α, income processes, government spending G/Y and debt B/Y relative to their GDP, and only differ in their baseline productivity level Θ^k and weight ω^k in the world basket.

In this symmetric country calibration, export weights are also consumption and GDP weights, that is, $\omega^k = \frac{C^k}{\sum_{l=1}^K C^l} = \frac{Z^k}{\sum_{l=1}^K Z^k} = \frac{Y^k}{\sum_{l=1}^K Y^l} = \frac{\Theta^k}{\sum_{l=1}^K \Theta^l}$, and world import demand is simply $C^* = \alpha \sum_{l=1}^K C^l$. Symmetry also requires that $\nu^k / \left(\omega^k\right)^\lambda$ and $\varphi^k / \left(\omega^k\right)^{1-\sigma}$ are equalized across countries, to ensure that steady state after-tax income Z^k scales with Θ^k and labor supply N^k is independent of Θ^k.

We calibrate each of these symmetric countries as a scaled version of the United States economy. In particular, we choose the income process and the degree of tax progressivity as in Auclert et al. (2018), and allow for heterogeneity in discount factors with a spread δ. We take our calibration targets to be consistent with our U.S. targets in our world-economy quantitative exercise of section 6. Government spending is $G/Y = 14\%$ of GDP, public debt is $B/Y = 82\%$ of GDP, and openness (backed out from the ratio of imports and exports to GDP) is $\alpha = 16\%$. We then calibrate β, δ to hit a real interest rate of $r = 0\%$ annually, as in recent experience, and a quarterly MPC of 0.25, consistent with evidence from a large literature on MPCs. Our calibrated parameters are summarized in table 1.

Small open economy case ($\Theta^k \to 0$). In section 3, we study an individual small open economy in our model. Mathematically speaking, a small open economy corresponds to a country with small productivity relative to the rest of the world ($\Theta^k \to 0$), and a correspondingly small demand for its goods in the world consumption basket ($\omega^k \to 0$). In this limit, all domestic aggregates scale with Θ^k and are therefore small themselves.[12] In particular, C^k and A^k are too small to affect any world aggregates in equations (30)–(34). Hence, any policy change in that country does not affect C_t^* or i_t^*. This result allows us to interpret the equations for an open-economy equilibrium given $\{C_t^*, i_t^*\}$ as relevant to

[12] Mathematically, as $\Theta^k \to 0$, $\left\{Y_t^k/\Theta^k, C_t^k/\Theta^k, A_t^k/\Theta^k, T_t^k/\Theta^k, Z_t^k\Theta^k, Q_t^k\right\}$ continues to constitute an open economy equilibrium given $\{C_t^*, i_t^*\}$.

understand the response to fiscal policy changes in small open economies.

Closed economy case ($K = 1$). When there is a single country ($K = 1$), then (31) reduces to $P_{Ht} = \mathcal{E}_t$, implying that $Q_t = 1$ and that $P_{Ht} = P_{Wt} = P_t$ at all times. By (13), $\pi_t = \pi_{wt}$. Combining (5), (20), and (21), total demand for domestic goods is simply domestic demand, $C_{Ht} + C^*_{Ht} = C_t$, and (32) reduces to domestic asset market clearing $A_t = B_t$. Hence this case collapses to a standard closed-economy heterogeneous-agent model with wage rigidities, the same as in Auclert et al. (2018).

Intertemporal MPCs (iMPCs). An important part of our analysis is to characterize household behavior in any given country. We do so by summarizing aggregate saving and consumption choices in terms of two functions, $\mathcal{A}_t$ and $\mathcal{C}_t$. These functions map the only two endogenous aggregate sequences that matter for household decisions—ex-ante[13] interest rates $\{r_s\}$ and after-tax incomes $\{Z_s\}$—into aggregate assets held by households and aggregate consumption,

$$A_t = \mathcal{A}_t\left(\{r_s, Z_s\}\right), \qquad C_t = \mathcal{C}_t\left(\{r_s, Z_s\}\right) \tag{36}$$

The two functions are naturally homogeneous of degree one in $\{Z_s\}$ and satisfy the aggregate budget constraint

$$\mathcal{C}_t + \mathcal{A}_t = \left(1 + r_{t-1}\right)\mathcal{A}_{t-1} + Z_t \tag{37}$$

Following Auclert et al. (2018), we define $\mathbf{M}$ as the matrix derivative (Jacobian) of the consumption sequence to the after-tax income sequence, evaluated at the steady state. That is, the entries of $\mathbf{M}$ are given by

$$M_{t,s} \equiv \frac{\partial \mathcal{C}_t}{\partial Z_s}\left(\{r, Z\}\right)$$

We call those entries *intertemporal marginal propensities to consume*, or *iMPCs*. iMPCs are a richer set of moments than standard marginal propensities to consume, in that they capture both the entire dynamic response of consumption to unanticipated income changes—the entries in the first column $(M_{\cdot,0})$ of $\mathbf{M}$—as well as the entire dynamic response of consumption to anticipated income changes—the entries in column s, $(M_{\cdot,s})$, for an anticipated income change at date $s > 0$.

[13] While it is the ex-post return r^p_t that directly enters the household's problem, in this model we have $r^p_t = r_{t-1}$ by equation (23).

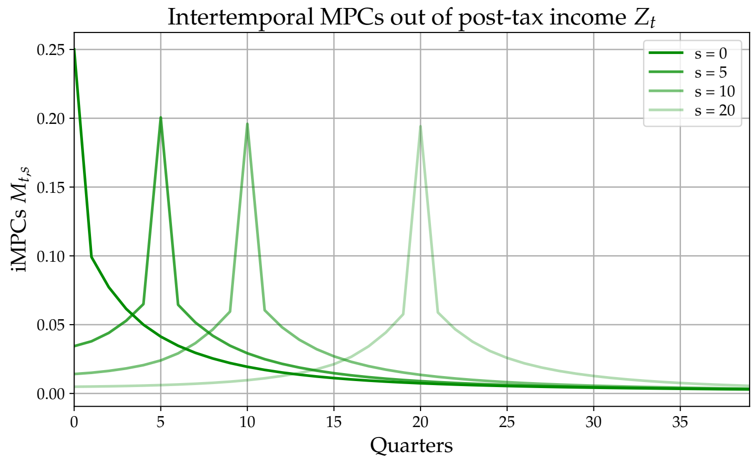


Figure 3: Intertemporal marginal propensities to consume $M_{t,s}$ (baseline calibration)

This information is critical to understanding the propagation of fiscal policy, since agents that do not immediately spend a given transfer may do so in later periods; and since agents may spend in anticipation of future transfers or income changes.

Figure 3 displays several columns of the iMPC matrix $\mathbf{M}$ in our baseline calibration. Each line corresponds to a different column s, giving the dynamic response of aggregate consumption to a one-time income change at date s. For example, the standard MPC is the immediate response to an unanticipated one-time unit income change and thus corresponds to the quarter-0 element of the darkest "$s = 0$" line. For future reference, we call this number $mpc \equiv M_{0,0}$; our calibration targets $mpc = 0.25$. The remaining unspent 0.75 of the unit income change is then endogenously spent in later periods. For instance, the iMPC in quarter 1 is around 0.10, and the total MPC in the first year is around 0.45. For income changes at later dates s, we see that despite some spending in anticipation of the income change, most of the spending response happens when the income is actually received. This is consistent with existing empirical evidence.

We next show that the iMPC matrix $\mathbf{M}$, together with the degree of openness α, are critical determinants of the propagation of fiscal policy in open economies.

3 Excess savings and twin deficits in a small open economy

In this section, we analyze fiscal policy in a small open economy ($\omega, \Theta \simeq 0$), with the world remaining at a steady state, with $i_t^* = r$ and $C_t^* = C^*$. In the next section, we will show that the outcomes of this small open economy model map directly to relative cross-country outcomes in the world economy model.

In addition to the standard effects of fiscal policy on output, inflation and exchange rates, we pay particular attention to the model's predictions for private saving and the current account. We will argue that these predictions are unique to models such as ours that combine stable long-run asset demand and home bias.

Specifically, we are interested in tracing out the response of private wealth A_t and the net foreign asset position nfa_t to a change in fiscal policy, as captured in our model by changes in the exogenous time paths of government spending G_t and debt B_t. We will say that an increase in public debt ($\Delta B_t \geq 0$) causes *excess savings* when it increases private wealth ($\Delta A_t \geq 0$) and that it causes a *twin deficit* when it leads to a deterioration in the net foreign asset position ($\Delta \text{nfa}_t \leq 0$). By the asset market clearing condition (27), the equilibrium response to an increase in B must involve a combination of excess savings and twin deficits. Our goal is to study which of these two prevails, and over what horizon.

A convenient way to describe this dynamic relationship is to study flows, i.e. saving and the current account, rather than stocks. These are determined in the model by goods market clearing, and can also naturally be mapped to the data. To this end, we define private saving PS_t, the current account CA_t and the fiscal deficit FD_t, respectively, as the change in the stocks of private wealth, the net foreign asset position, and public debt:

$$PS_t \equiv A_t - A_{t-1} \qquad CA_t \equiv \text{nfa}_t - \text{nfa}_{t-1} \qquad FD_t \equiv B_t - B_{t-1}$$

It follows from asset market clearing (27) that $FD_t = PS_t - CA_t$, so an increase in the fiscal deficit must be matched by an increase in private saving or a decline in the current account.

We focus on the case of a zero steady state net interest rate, $r = 0$, for now. This is consistent with our calibration and greatly simplifies the analytical expressions.[14] We relax this assumption in appendix B.4.

3.1 Long-run result

Our first result concerns the long-run effects of fiscal policy. Assume that the economy is initially at a steady state, with government spending G_{ss}, debt level B_{ss}, real interest rate r_{ss} and post-tax income Z_{ss}. Suppose that fiscal policy changes, such that in the long run government spending is $G = G_{ss} + \Delta G$ and debt is $B = B_{ss} + \Delta B$. How does this affect the economy's steady state?

The key to answering this question is to consider the determinants of the long-run

[14]Since the counterpart of this condition in a model with long-run growth is r equal to the growth rate, this is also empirically relevant, as has been widely argued (see e.g. Blanchard 2019).

level of private wealth. In any steady state, (36) shows that this level is a function $A(r, Z)$ of the long-run real interest rate r and the level of post-tax income Z. Combining this observation with the steady-state market clearing condition (27), we obtain:

$$A(r, Z) = B + \text{nfa} \tag{38}$$

The left-hand side of (38) is long-run domestic asset demand, determined by the long-run real interest rate and level of post-tax income. The right-hand side is domestic asset supply, here made of bonds, plus the net foreign asset position. Building on this observation, the following proposition solves for the long-run effect of fiscal policy.

Proposition 1. *Assume that $r = 0$ and that the economy converges back to the natural allocation in the long run. Suppose that long-run government spending is unchanged $\Delta G = 0$, and that government debt increases by ΔB. Then, the long-run features an unchanged real exchange rate $\Delta Q = 0$, an unchanged level of real income $\Delta Z = 0$, as well as zero excess savings and a perfect twin deficit:*

$$\Delta A = 0 \qquad \Delta nfa = -\Delta B$$

In particular, the long-run "pass-through" of public debt into the net foreign asset position is $LRPT = -\frac{\Delta nfa}{\Delta B} = 1$.

If government spending increases by a small amount dG in addition to a small debt increase of dB, then to first order, the real exchange rate changes by $\frac{dQ}{Q} = -\frac{1-\alpha}{\chi-1}\epsilon\frac{dG}{Y}$ and excess savings and twin deficits are given by:

$$dA = -\epsilon \cdot A \cdot dG \qquad dnfa = -\left(dB + \epsilon \cdot A \cdot dG\right)$$

where $\epsilon \equiv \left(\frac{\sigma-1}{1+\varphi} + \left(1 - \frac{G}{Y}\right)\left(1 + \frac{\alpha}{\chi-1}\right)\right)^{-1}$ and $\chi \equiv \eta(1-\alpha) + \gamma$.

The key to this proposition is that, under our assumptions, a change in long-run B at constant long-run G does not change either the long-run real interest rate or the level of after-tax income ($r = r_{ss}$, $Z = Z_{ss}$). The real interest rate is unaffected because the economy is too small for its fiscal policy to affect the rest of the world, and after-tax income is unaffected because, at $r = 0$, no local tax increase is necessary to finance the increase in B. Hence, irrespective of how much fiscal policy affects private wealth in the short run, the long run level of private wealth is unchanged at $A(r, Z)$, and the increase in B is therefore entirely absorbed by foreigners.

Note that this result is true irrespective of the monetary policy that is followed along the path (assuming that it gets the economy back to the natural allocation), and irrespective of what is done with the fiscal expansion along the path (government spending or transfers, provided that government spending is back at steady state in the long run). The logic behind it is very general, and only relies on the existence of a stable long-run asset demand function $A(r, Z)$. For instance, an identical result would hold if we added capital to our model, or if the household model generated a long-run asset demand function $A(r, Z)$ for some other reason than our benchmark of precautionary savings and borrowing constraints. We come back to the question of which models fit this bill in section 3.4.2.

If government spending G changes in the long run, the real exchange rate Q, consumption C and real income Z are affected. If real income declines as a result of this increase in G, as happens under plausibly high long-run elasticities (for instance, $\sigma \geq 1$ and $\chi \geq 1$), then the long-run pass-through of public debt into the net foreign asset position $LRPT = -\frac{d\text{nfa}}{dB}$ is even greater than 1, due to the combination of reduced asset demand and increased asset supply.

3.2 Short-run dynamics without a monetary policy response

Proposition 1 shows that any increase in public debt in a small open economy with a well-defined long-run asset demand function $A(r, Z)$ is eventually entirely held abroad. However, this cannot happen right away. By the balance of payments identity (29), a deterioration in the net foreign asset position requires a sequence of trade deficits, in the form of higher imports or lower exports. In turn, the change in imports and exports must be induced by the change in fiscal policy.

Here, we characterize analytically this transition. We stack the entire paths of government spending $\{dG_t\}$ and public debt $\{dB_t\}$ into vectors, which we denote by $d\mathbf{G} = (dG_0, dG_1, \ldots)$ and $d\mathbf{B} = (dB_0, dB_1, \ldots)$, and similarly for other variables. We then solve for the first-order impulse response of all macroeconomic aggregates to this change.

Solving for the transition requires an assumption about monetary policy. In this section, we consider the case of "no monetary response", in which monetary policy maintains a constant r throughout, i.e. (17), with $r = 0$. We also assume that any government spending change is transitory, so that $\lim_{t\to\infty} dG_t = 0$. Under these conditions, we know from proposition (1) that the long-run real exchange rate $\lim_{t\to\infty} Q_t$ is unchanged and equal to $Q = 1$. Combined with the real UIP condition (22), and given $i_t^* = r = 0$, it then follows that the entire path of real exchange rates is unchanged, as well:

$$Q_t = \frac{P_{Ht}}{P_t} = 1 \quad \forall t \tag{39}$$

This result implies that any causal effect of fiscal policy on the trade balance must go through changes in import demand, rather than through expenditure switching. In section 3.4 we consider alternative monetary policy rules, in which expenditure switching also plays a role.

Since $r_t = 0$ for all t, the government budget constraint (14) implies that the fiscal deficit FD_t is also the primary deficit, i.e.:

$$FD_t = B_t - B_{t-1} = \frac{P_{Ht}}{P_t}\left(G_t - T_t\right) = G_t - T_t \tag{40}$$

Recall that our equilibrium takes as exogenous the path of government spending and the path of public debt B_t (or, equivalently, fiscal deficits FD_t). By equation (40), any increase in the fiscal deficit that is not used to finance government spending leads to lower taxes, i.e. transfers to households.

The next two propositions consider the first-order effect of exogenous changes in $d\mathbf{G}$ and the fiscal deficit $d\mathbf{FD}$. We begin with the case without home bias, and then consider the case with home bias.

3.2.1 Case with no home bias ($\alpha \to 1$)

In the limit with no home bias $\alpha \to 1$, the following proposition summarizes the effect on our outcomes of interest.

Proposition 2. *Assume constant-r monetary policy, $r = 0$, $\lim_{t\to\infty} dG_t = 0$, and no home bias $\alpha \to 1$. Then, the first-order responses of output $d\mathbf{Y}$, the current account $d\mathbf{CA}$, and the trade deficit $d\mathbf{TD}$ are given by:*

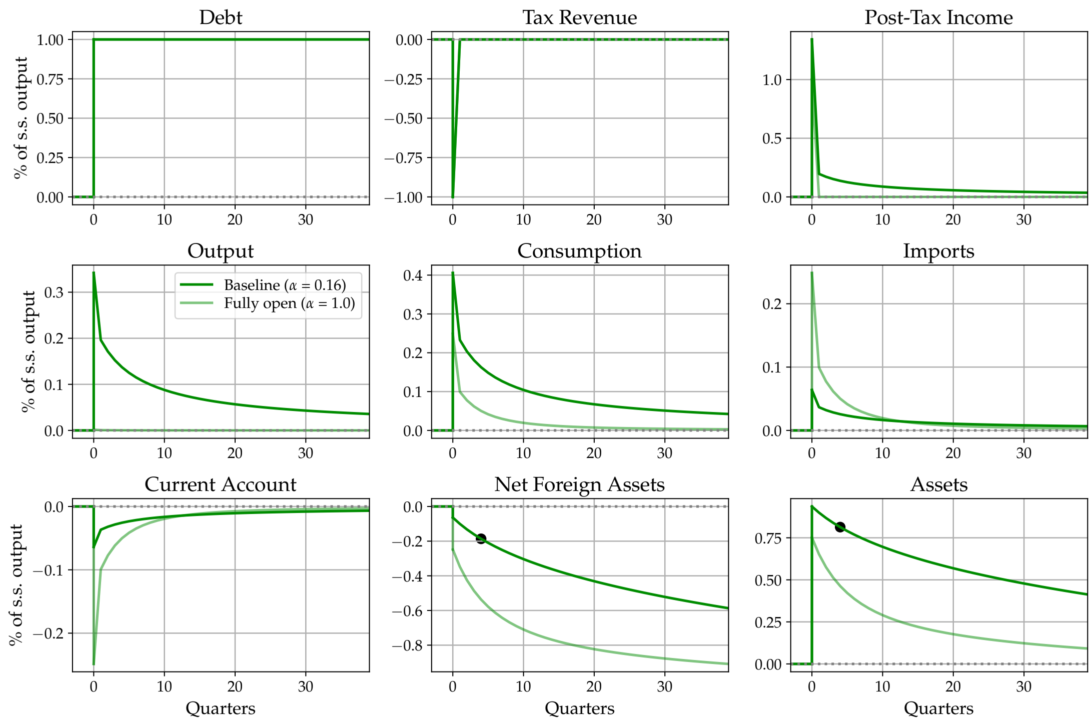
$$d\mathbf{Y} = d\mathbf{G} \tag{41}$$

$$-d\mathbf{CA} = d\mathbf{TD} = \mathbf{M}d\mathbf{FD} \tag{42}$$

$$d\mathbf{PS} = \left(I - \mathbf{M}\right) d\mathbf{FD} \tag{43}$$

Equation (41) shows that the effect on domestic output only depends on local government spending, with a fiscal multiplier of 1. Equation (42) shows that fiscal deficits cause a current account and trade deficit (a "twin deficit") with a dynamic pass-through exactly equal to the iMPC matrix $\mathbf{M}$. Equation (43) shows that fiscal deficits cause a rise in private saving ("excess saving") with a pass-through given by the matrix of intertemporal marginal propensities to save, $I - \mathbf{M}$.

The logic behind these results is as follows. Consider first the case where local gov-



Note: The black dots on the Net Foreign Asset and Asset impulse responses correspond to the predictions of the baseline model for the empirical regressions discussed in Section 5.

Figure 4: Impulse response to a debt-financed transfer under different degrees of openness α

ernment spending changes without a change in the fiscal deficit, so that the government raises taxes contemporaneously. Equation (41) shows that this affects local GDP one for one with the rise in spending. This result is made possible by our monetary policy assumption: see Woodford (2011) for the representative-agent case and Auclert et al. (2018) for the heterogeneous-agent case in a closed economy setting. The additional spending causes pre-tax incomes to increase by as much as taxes do, and since these have the same incidence across the population, there is no effect on post-tax incomes for anyone, and therefore no effect on either private savings or private spending.

Next, consider the case where the fiscal deficit changes. Combining equations (16) and (40), we see that this change affects post-tax incomes by the magnitude of the fiscal deficit, $d\mathbf{Z} = d\mathbf{Y} - d\mathbf{T} = d\mathbf{G} - d\mathbf{T} = d\mathbf{FD}$. The matrix of intertemporal marginal propensities to consume then determines how much is saved and goes into private saving $(I - \mathbf{M})\, d\mathbf{FD}$, and how much of it is spent ($\mathbf{M}d\mathbf{FD}$). Importantly, because there is no home bias, all spending is on foreign goods, and therefore affects the trade and current account deficits one for one.[15]

The dark green line in figure 4 illustrates this logic in the case of a one-time, permanent shock to the debt level, as visualized in the top left panel. This is an especially instructive case to understand equilibrium adjustment, and corresponds to the typical case in which public debt rises because the government sends one-off transfers to households. Here, the path of current account deficits is exactly equal to that of iMPCs out of unanticipated transfers in figure 3. In particular, the impact effect on the current account deficit of a unit change in dB is equal to 0.25. The net foreign asset position follows the cumulative iMPCs $\sum_{s=0}^{t} M_{0s}$. Since households' intertemporal budget constraints imply that $\sum_{s=0}^{\infty} M_{0s} = 1$, in the long run we obtain a pass-through of 1, confirming proposition 1.

The reason why MPCs matter here is straightforward: in the aggregate, a fiscal deficit increase of \$1 leads households to receive \$1 in transfers, out of which they immediately spend $M_{0,0}$ dollars. Since there is no home bias, all of this is extra spending is on imports, leading to a current account deterioration on impact of $M_{0,0}$. Taking stock, the short-run "pass-through" of the fiscal deficit into the current account deficit when there is no home bias is:

$$SRPT^{\alpha=1} = \frac{-dCA_0}{dFD} = \frac{-d\mathrm{nfa}_0}{dFD} = M_{0,0}$$

As households keep spending down their excess savings and the spending response builds up, imports remain elevated and the current account remains in deficit, until the point at which the country has accumulated a foreign debt equal to the increase in government debt.

This discussion illustrates the importance of iMPCs in disciplining the time path of twin deficits. There is a great deal of evidence that iMPCs are elevated not just at times when households receive the transfers, but also afterwards, as in figure 3. One general equilibrium implication of this fact for open economies is that we expect current account deficits to be more persistent than fiscal deficits.

3.2.2 General case with home bias ($0 < \alpha < 1$)

The next proposition provides the impulse responses in the more general case with home bias $0 < \alpha < 1$.

Proposition 3. *Assume constant-r monetary policy, $r = 0$, and $\lim_{t\to\infty} dG_t = 0$. Then, the first-order responses of output $d\mathbf{Y}$, the current account $d\mathbf{CA}$, and the trade deficit $d\mathbf{TD}$ are related*

[15] The same logic would prevail in an endowment economy with a single worldwide good, as in the canonical Blanchard (1985) model, rather than in our model with a produced good and our particular assumption about monetary policy.

to the iMPC matrix $\mathbf{M}$ *and openness* α *via:*

$$d\mathbf{Y} = d\mathbf{G} + (1-\alpha)\,\mathbf{M}\left(\sum_{k\geq 0}(1-\alpha)^k\,\mathbf{M}^k\right)d\mathbf{FD} \tag{44}$$

$$-d\mathbf{CA} = d\mathbf{TD} = \alpha\mathbf{M}\left(\sum_{k\geq 0}(1-\alpha)^k\,\mathbf{M}^k\right)d\mathbf{FD} \tag{45}$$

$$d\mathbf{PS} = (I-\mathbf{M})\left(\sum_{k\geq 0}(1-\alpha)^k\,\mathbf{M}^k\right)d\mathbf{FD} \tag{46}$$

The proof is in appendix B.2. This result can be seen as a combination of the closed-economy analysis of fiscal policy in Auclert et al. (2018) and the open-economy analysis of exchange rates and monetary policy in Auclert et al. (2021c).

Just as in proposition 2, and for the same reason, a balanced-budget change in government spending has a one-for-one effect on output. However, with home bias, the response to fiscal deficits is different. Consider now a change in the time path of fiscal deficits with no change in government spending $d\mathbf{G} = 0$, so that all that changes is transfers to households $-d\mathbf{T} = d\mathbf{FD}$. Households still spend these transfers according to their MPCs. But now, a fraction $1-\alpha$ of this additional spending is used to purchase domestic goods, which boosts country income, and is therefore spent again. The resulting effect on output is that of a standard Keynesian cross, but here each round of spending affects the time path of output according to $((1-\alpha)\,\mathbf{M})^k$. This explains the right-hand sides of equations (44)–(46), which correspond to the general equilibrium change in total post-tax income induced by the change in the fiscal deficit.

Apart from these general equilibrium effects on income, the key difference to proposition 2 is that, now, the response of the current account deficit is characterized by $\alpha\mathbf{M}$ rather than $\mathbf{M}$. This effect is critical to slow down the pass-through of the fiscal deficit to the current deficit. To understand this effect quantitatively, consider again a one-time, permanent shock to the debt level, as visualized in the light green line of figure 4 for our baseline calibration to $\alpha = 0.16$.

Here also, the direct effect of a fiscal deficit of \$1 is that households receive \$1, of which they spend $M_{0,0}$ \$. However, only $\alpha \times M_{0,0}$ \$ is spent on imports. This is much smaller in practice than $M_{0,0}$. This explains why the impact effect on the current account deficit in figure 4 is much below 0.25. Because of the general equilibrium effect on output, however, this effect is higher in absolute value than $\alpha \times M_{0,0}$. One simple way to understand this adjustment process is to think about a case where households do not anticipate any future increases in income.[16] In this case, the short-run pass-through parameter would be:

$$SRPT^{na} = \frac{\alpha \cdot M_{0,0}}{1 - (1-\alpha) M_{0,0}} \tag{47}$$

This is still much smaller than $M_{0,0}$ for any realistic calibration of mpc and α. Taking account of the dynamic effects requires using the full expression for the current account in equation (45). If we let $\mathbf{e}_0' = \begin{pmatrix} 1 & 0 & 0 & \cdots \end{pmatrix}$ be the vector with one as the first element and zeros everywhere else, the full expression for the pass-through is:

$$SRPT = -\alpha \mathbf{e}_0' \left(I - (1-\alpha) \mathbf{M}\right)^{-1} \mathbf{M}\mathbf{e}_0 dB \tag{48}$$

In practice, the $SPRT$ from this expression is only slightly above $\alpha \times M_{0,0}$ (see figure 4). This implies a slow buildup of the foreign ownership of debt.

Taking stock, the combination of limited MPCs and home bias leads to slow transition dynamics in response to increases in public debt.

3.3 Who holds the new assets? The three phases of ownership

An advantage of our HANK model is that it allows us to trace out the cross-sectional patterns that underlie any fiscal expansion. Figure 5 traces out the dynamics of ownership that underlie the one-time debt-expansion experiment in figure 4. The dark purple area corresponds to the increase in wealth for the top 20% of the wealth distribution at each point in time (henceforth "the rich").The light purple area corresponds to the wealth increase for the next 80% (henceforth "the middle class"). Together, these two sum to the "Asset" line in figure 4. Finally, the blue area corresponds to the negative of the net foreign asset position, i.e. the amount of the marginal public debt held by foreigners.

The left panel of figure 5 considers the case with no home bias, $\alpha \to 1$. Initially, middle-class and rich both increase their savings in response to the transfers, but the middle class spends down these savings much more quickly than the rich. One can summarize these dynamics in *three phases*: First, private wealth rises for all households; then, it remains elevated only for rich households; and eventually, all debt is held by foreigners.

The right panel of figure 5 displays the same outcomes in our baseline calibration with $\alpha = 0.16$. Here, the three phases are even more pronounced: as the middle class initially spends down their transfers, economic activity rises, which allows the rich to keep increasing their savings as the middle class spends theirs down. This phenomenon relies

[16] We explicitly spell out this "no anticipation" model in appendix B.3.

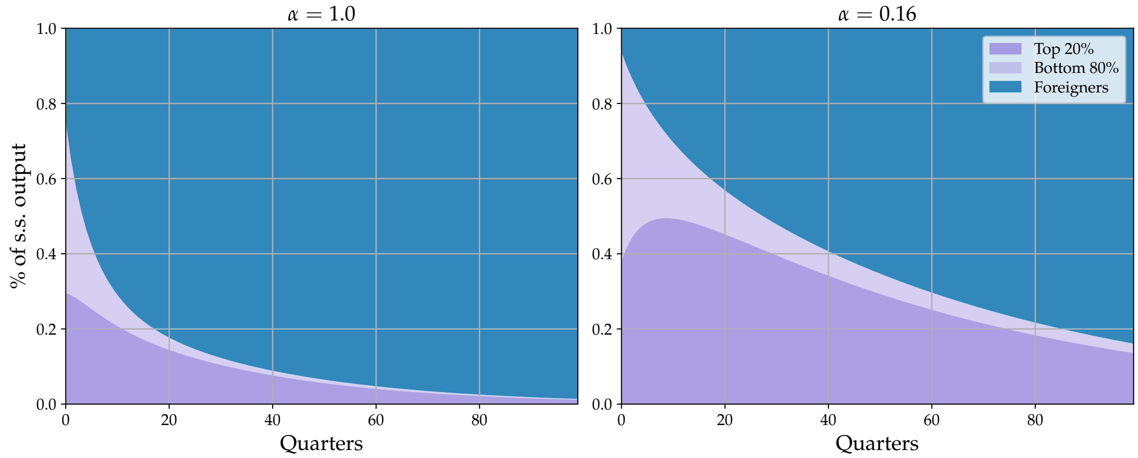


Figure 5: Three phases of asset ownership in the small open economy

on the output boom from the spending, and is therefore not present in the left panel.[17]

3.4 Extensions

We now consider two extensions. In the appendix, we also consider the case where $r \neq 0$, as well as alternative distributions for transfers.

3.4.1 Monetary policy response

We next consider alternative monetary policies, deviating from the constant-r rule in (17). We study a Taylor rule targeting home goods inflation (18), and the natural allocation that induces a zero domestic inflation path at all times (19). Figure 6 shows the results of simulations under these alternative monetary policy rules. Because the fiscal shock is inflationary, under these rules it induces a monetary tightening whose main effect is to reduce the output response. Import demand is consequently reduced. However, the current account dynamics (and therefore those of net foreign assets) are very similar to the constant-r case. This is because the appreciation of the real exchange rate from the monetary tightening reduces net exports via expenditure switching.

It is possible to further understand these dynamics by considering the separate effects of the real exchange rate $d\mathbf{Q}$ and total consumption demand $d\mathbf{C}$ on the trade and current account deficit. Appendix B.2 shows that we always have:

$$-d\mathbf{CA} = \frac{-\alpha}{1-\alpha} C\left(\chi - 1\right) d\mathbf{Q} + \alpha d\mathbf{C} \tag{49}$$

[17] If a monetary response—such as in the upcoming section 3.4.1—limits the output boom, we still see a similar effect, now because the rich increase their savings in response to the higher interest rate.

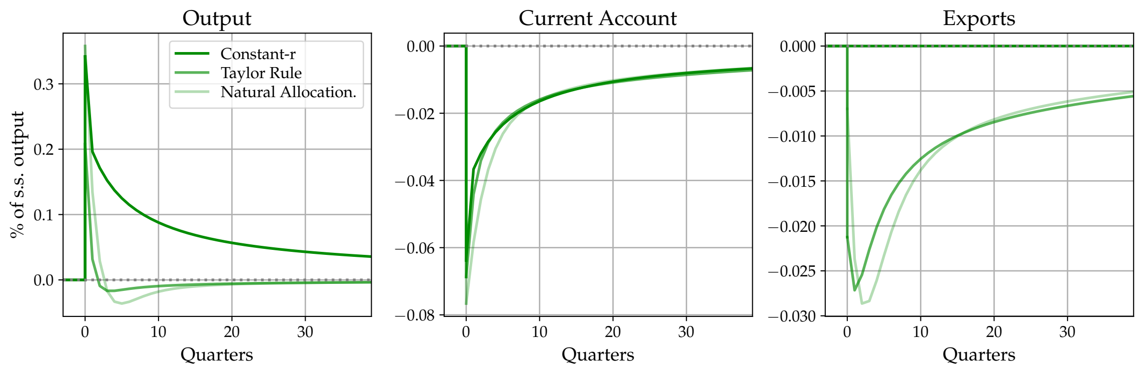


Figure 6: Impulse response to a debt-financed transfer under alternative monetary policy rules

where $\chi = (1-\alpha)\,\eta + \gamma$ is the sum of import and export elasticities. Other things equal, the appreciation deteriorates the current account provided that $\chi > 1$, an effect that can counterbalance the decline in import demand from the direct effect of monetary policy on spending. In our calibration, these two effects almost exactly offset each other.[18]

Note that the natural allocation features a twin deficit phenomenon exactly like under our constant-r monetary rule. This shows that nominal rigidities are not important for our main results.

3.4.2 Alternative models: RANK, TANK and Blanchard (1985)

Having discussed the time paths of asset ownership in our baseline model, we now consider the implications of alternative widely-used models, beginning with a representative-agent model. There, Ricardian equivalence implies that any increase in debt immediately results in excess savings, as illustrated in the left panel of figure 7. A_t tracks B_t perfectly.[19]

A more involved question is whether alternative non-Ricardian models also deliver a similar response. We consider two of the main leading non-Ricardian models in the literature, which act as tractable alternatives to heterogeneous agent models: a TANK model as in Galí et al. (2007) and Bilbiie (2008); and a perpetual youth model along the lines of Blanchard (1985).

In appendix B.6, we study the TANK model, which is made up of a fraction μ of

[18] This result is specific to our calibration of trade elasticities to $\eta = \gamma = 1$. Under this parameterization, and in a setting with $\sigma = 1$ (i.e. the Cole-Obstfeld case) and assets that represent capitalized claims on the (constant) share of future profits, proposition 6 in Auclert et al. (2021c) shows that in general equilibrium, changes in the real interest rate $d\mathbf{r}$ have no effect on the current account (echoing a similar result in Galí and Monacelli 2005). Here, assets are bonds rather than capitalized profits, so this result does not hold exactly, but figure 6 shows that it holds approximately.

[19] Observe that $r = 0$ is strictly speaking not possible to achieve in a representative agent model, but $A_t = B_t$ holds irrespective of the steady state interest rate assumed in a representative agent model.

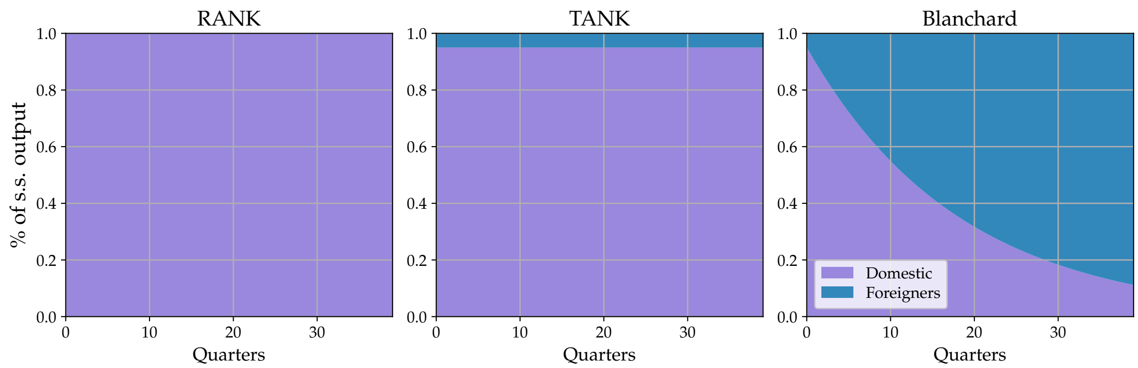


Figure 7: Impulse response of assets to a debt-financed transfers in alternative models

hand-to-mouth agents and a fraction $1-\mu$ of standard infinitely-lived unconstrained consumers. We show that, in this model, the twin deficits equation (45) reduces to:

$$-d\mathbf{CA} = \frac{\mu\alpha}{1-\mu\left(1-\alpha\right)}d\mathbf{FD}$$

Here, the "no anticipation" logic that governed equation (47) applies not only to the impact effect, but at every point in time. Therefore, the TANK model provides backing for the classical twin deficit hypothesis, in which fiscal deficits translate into current account deficits at the same point in time. However, the quantitative magnitudes from this particular microfounded model are difficult to reconcile with the "rules of thumb" typically used by policy institutions. For realistic calibration, even if $\mu = 0.25$, at our U.S. calibrated value for openness of $\alpha = 0.157$, we find a pass-through of only about 5%, much smaller than the 30%-50% range often assumed. In the limit with $\mu = 0$, this becomes the representative-agent model with Ricardian equivalence and no impact of the fiscal deficit on the current account deficit.

Note further that the TANK model has very different dynamic behavior from our HANK model. In the TANK model, the current account deficit only lasts for as long as the transfers last (when hand-to-mouth agents spend it), so the long-run pass-through is just $\frac{\mu\alpha}{1-\mu(1-\alpha)} \ll 1$. This is illustrated in the middle panel of figure 7.

A model that behaves much closer to the HANK model is the well-known Blanchard (1985) model, which was first introduced to study analytically the effects of debt on the current account, albeit in a one-good setting. In appendix B.7, we write down the discrete time counterpart of this model. We show that it features a consumption and asset function as in (36), whose $\mathbf{M}$ matrix can be characterized in closed form, as well as a closed form long-run asset demand function $A\left(r, Z\right)$. The model's parameters can be calibrated to hit $M_{0,0}$ directly. The model also features a LPRT of 1, and its main difference in dynamics are due to the fact that it has a different $\mathbf{M}$ even when calibrating to the same $M_{0,0}$. Figure 7 illustrates how similar the Blanchard model is to the baseline HANK model once matched to the same mpc and α. Here, the decay in net foreign assets is faster than in the HANK model, because $M_{0,1}$ is larger in the Blanchard model.[20]

3.5 Can a Covid shock explain excess savings and the current account?

We have seen that a fiscal deficit shock does a good job at qualitatively matching the patterns of figures 1 and 2: it is accompanied by a large increase in private savings with realistic distributional dynamics, and by a limited decline in the current account deficit that happens in slow motion.

It is often argued that the increase in private savings documented in figure 1 is not just the result of fiscal policy, but also of pandemic restrictions (e.g. Goldman Sachs 2021, TD Bank 2021, European Central Bank 2021.) Here, we show that this argument misses an important part of general equilibrium: Covid restrictions that depress consumption also depress income, so that the effect of these restrictions on aggregate excess saving were likely small.[21] We demonstrate this logic in our model using two different types of shocks to proxy for the idea that the Covid shock depressed spending.

We first consider a shock to overall spending, in the form of a shock to the discount factor β of all households in the small open economy. This shock depresses desired spending and therefore equilibrium spending, with households cutting back on both domestic and foreign spending alike. We solve for the response of the model under the constant-r monetary policy scenario, under our baseline calibration of $\alpha = 0.16$.

We calibrate this shock such that it implies a realistic decline in the level of output. In the United States, in 2020Q2, the level of output was 9% below where it had been in 2020Q1, and it had essentially entirely recovered by 2021Q2. Of course, some of this recovery was the sustained effect of the US fiscal stimulus. Using our quantitative model from section 6, we infer that fiscal policy sustained the level of output by around 3% for about two years. This implies that the pure effect of the Covid shock, absent fiscal policy, would have been to lower output by 12% in 2020Q2 and 3% in 2021Q2. We fit the standard

[20] This is due to the lack of selection into spending: unlike in TANK and HANK, where households that choose not to spend have lower propensities to spend in the future, the MPC out of excess savings is constant in the Blanchard model. We could improve the Blanchard model's fit to the $\mathbf{M}$ matrix by adding hand-to-mouth agents, since as appendix B.8 shows it is locally isomorphic to a bond-in-utility model, and Auclert et al. (2018) show that a mixture of bond-in-the utility and hand-to-mouth agents (a "TABU" model) closely approximates the $\mathbf{M}$ matrix of a HANK model

[21] To simplify the argument, in this section we focus on levels in a small open economy rather than on cross-country outcomes.

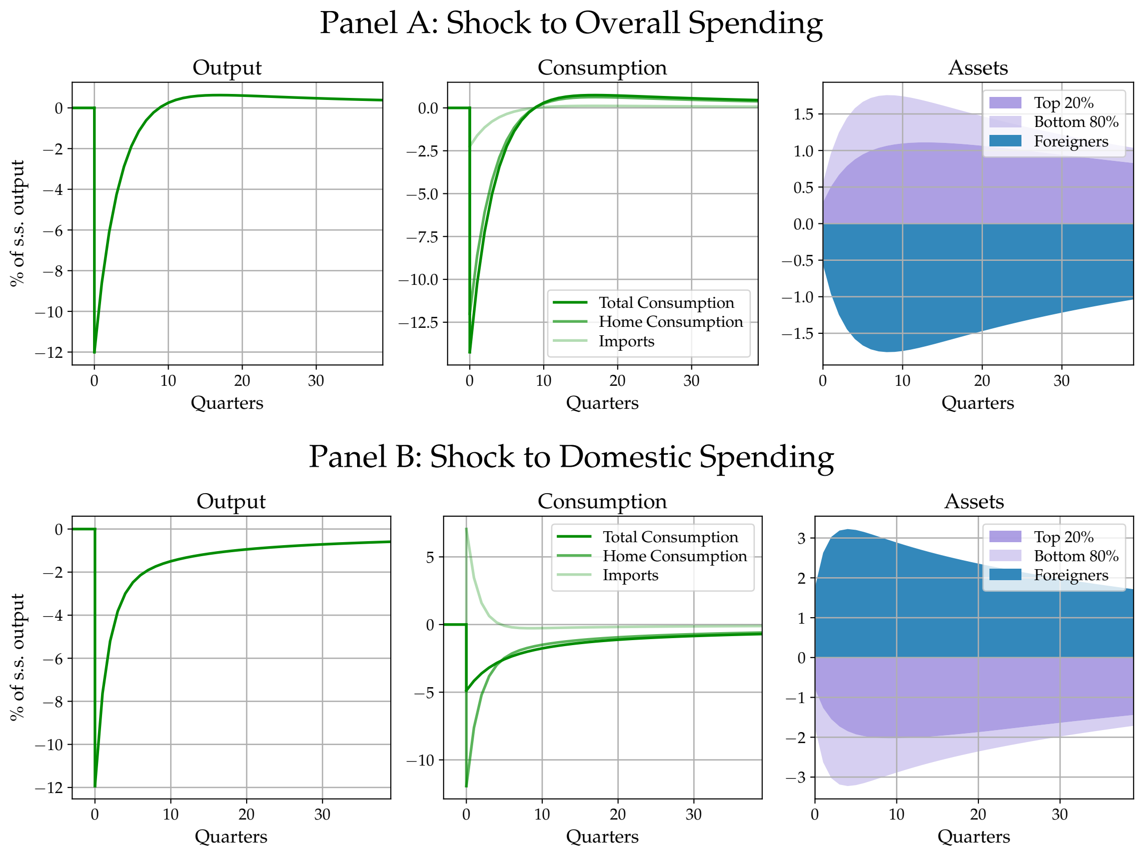


Figure 8: Impulse responses to two Covid shocks

deviation and persistence of an AR(1) shock to β to match these numbers. The resulting effect is displayed in Panel A of figure 8.

We do find that a shock to overall spending can lead to aggregate excess savings. The shock implies a decline in both home and foreign spending. The decline in home spending lowers GDP and domestic income, with no net effect on saving. The decline in foreign spending, however, leads to a current account surplus. In the aggregate, absent a rise in fiscal deficits or investment, a current account surplus is the only way in which the country can build up excess savings. Note, however, from the right panel, that the magnitude of this effect is very small: a 12% decline in GDP only leads to a peak increase of cumulative excess savings of about 1.5%, which is small compared to the observed increase of about 11% in figure 10.

A widely-noted aspect of the pandemic is that it has unequally hit sectors, with services being much harder-hit, such that the pandemic created a reallocation of activity towards goods and away from services (e.g. Baqaee and Farhi 2022, Guerrieri, Lorenzoni, Straub and Werning 2022.) This suggests that an overall shock to desired spending is not the most appropriate way of modeling the Covid shock. We therefore modify equation

(1) to feature a shock ζ_t to home spending

$$c_{it} = \left[(1-\alpha)^{\frac{1}{\eta}} \left(\zeta_t c_{iHt}\right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(c_{iWt}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

and solve for the general equilibrium effect of this shock.[22] We recalibrate the model to feature a low intratemporal elasticity relative to the intertemporal elasticity ($\eta = 0.5 < 1 = \sigma^{-1}$) such that the shock has a general equilibrium effect on home output (see Guerrieri et al. 2022 for a similar condition.) We calibrate an AR(1) ζ_t shock to match the same output decline as described previously.

Panel B of figure 8 displays the effect of this shock. As expected, the shock leads to a decline in home spending and a reallocation of spending towards imports. Hence, now in equilibrium the current account and excess savings actually decline in equilibrium, with "excess dissavings" of about 3% of GDP at the peak.

Overall, this shows that the Covid shock itself may have limited general equilibrium effects on saving, because it reduces income along with consumption. Whether income or consumption declines more depends on the exact details of the shock, but the magnitude of the rise in saving falls well short of the data even in the (somewhat unrealistic) scenario that gives the most chance to this idea.

4 Fiscal deficits in the world economy

In the last section, we discussed a small open economy changing fiscal policy in isolation. In practice, however, the Covid fiscal expansion that motivates this paper happened simultaneously across all countries. This renders the small open economy analysis incomplete. For instance, while one country can borrow from the rest of the world—as predicted by proposition 1—to finance its new debt, collectively the world cannot. Instead, after an increase in world debt, some mechanism must convince agents collectively to buy the new debt. In our model, that mechanism is a rising world interest rate.

In this section, we characterize the world-economy equilibrium. We maintain our baseline symmetric-country calibration, with export weights ω^k equal to GDP weights. In this environment, we show analytically that our small open economy results remain highly relevant, because they characterize the *deviations* of each country from the world average. They can either be combined with closed-economy results to obtain the world equilibrium, or brought directly to the cross-sectional data.

[22] Details are provided in appendix B.9.

4.1 A decomposition result for the world economy

In our symmetric-country calibration, all variables are either constant across countries k in the steady state (e.g. i^k or Q^k), or scale with each country's relative GDP ω^k (e.g. C^k or Y^k). We define aggregate and demeaned versions of both kinds of variables.

Definition 3. Define *aggregate* and *demeaned* variables as follows:

- For all variables that are constant across countries in the symmetric steady state, e.g. i_t, the *aggregate* is the weighted sum, e.g. $i_t \equiv \sum_k \omega^k i_t^k$, and the *demeaned* is the deviation from the aggregate, e.g. $\tilde{i}_t^k = i_t^k - i_t$.
- For all variables that scale with ω^k across countries in the symmetric steady state, e.g. C_t^k, the *aggregate* is the overall sum across countries, e.g. $C_t \equiv \sum C_t^k$, and the *demeaned* is the scaled deviation from the aggregate, e.g. $\tilde{C}_t^k = \frac{C_t^k}{\omega^k} - C_t$.

We then have the following first-order *decomposition result* for the world equilibrium.

Proposition 4. *Consider a symmetric world economy hit by shocks, e.g. $d\mathbf{B}^k$, in each country k. The first-order impulse responses of variables in each country satisfy the following property. First, aggregate variables are given by the closed economy model in response to the aggregate shocks, e.g. $d\boldsymbol{B}$. Second, all demeaned variables in country k are given by the small open economy model in response to the demeaned shocks, e.g. $d\tilde{\mathbf{B}}^k$.*

This powerful result decomposes the response to shocks in the world economy into two simpler cases introduced in section 2: first, the closed economy, which characterizes the response of world aggregates, and second, the small open economy, which characterizes the response of deviations relative to the world. The former allows us to draw on existing closed-economy work to understand the evolution of the world as a whole, while the latter allows us to reinterpret the results of section 3 as characterizing relative outcomes across countries.

The intuition for proposition 4 is that collectively, the world cannot run a current account deficit against itself, nor can it change its real exchange rate relative to itself. Hence, when we combine variables across countries to obtain world aggregates, the world behaves like a closed economy. At the same time, all countries face the same world import demand C_t^* and interest rate i_t^* at every date. Hence, to first order, relative outcomes across countries should be unaffected by changes in C_t^* and i_t^*, and should be the same as implied by the small open economy model, which holds C_t^* and i_t^* fixed.

In the next two sections, we apply proposition 4 to study the transmission of fiscal shocks, both in the long run and in the transition.

4.2 Application: long run

We now assume that each country conducts a small, permanent fiscal expansion of dB^k. In the interest of space, we focus on the case where we initially have $r = 0$, and countries do not increase long-run government spending, $dG^k = 0$. We then have the following corollary of propositions 1 and 4.

Corollary 1. *Assume that $r = 0$; that $dG^k = 0$; that the government of country k with GDP weight ω^k expands its long-run debt by dB^k; and that all economies go back to the natural allocation in the long-run. Then, to first order, in each country the long-run real exchange rate is unchanged ($dQ^k = 0$), real income changes by the same proportion everywhere, $d\log Z^k = d\log Z$, and letting $B = \sum_k B^k$, we have the same amount of excess savings everywhere and a twin deficit in higher-debt countries:*

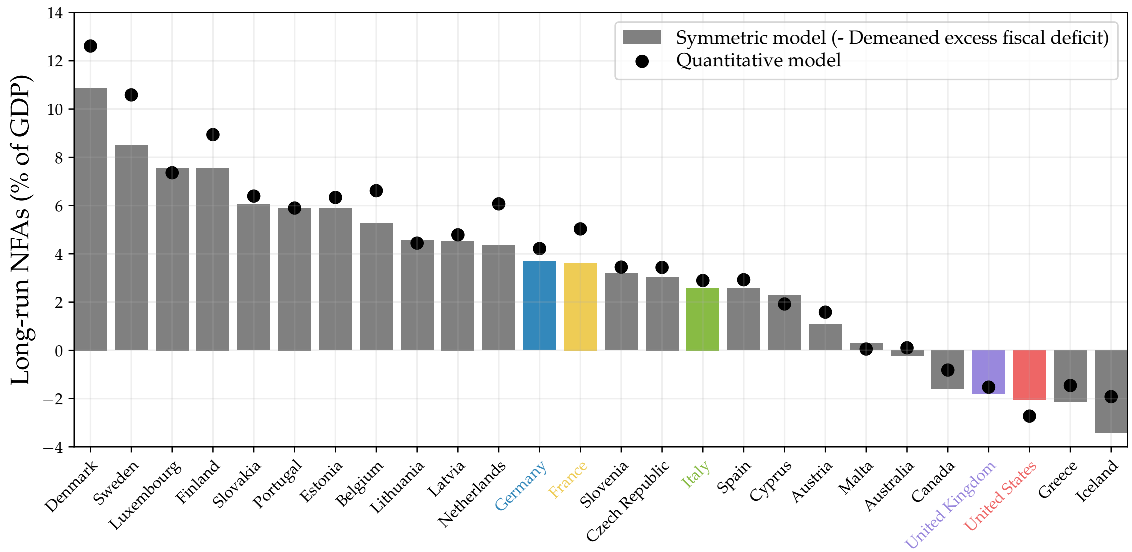
$$d\log A^k = d\log B \qquad dnfa^k = -\left(dB^k - \omega^k dB\right) \tag{50}$$

In particular, the long-run pass-through of public debt to the NFA is $LPRT = 1 - \omega^k$. Letting $a(r) \equiv A(r, Z)/Z$ denote normalized asset demand, the increase in the world interest rate that sustains this equilibrium is:

$$dr^n = \frac{d\log B}{\frac{d\log a(r)}{dr} - \frac{1+\frac{1}{1-\frac{G}{Y}}\frac{\sigma}{1+\phi}}{1-\frac{1}{1-\frac{G}{Y}}\frac{1-\sigma}{1+\phi}}a(r)} \tag{51}$$

Proof. It follows from proposition 4 that demeaned variables will have the impulses characterized in the small open economy by proposition 1, so that steady-state demeaned assets, real exchange rates, real interest rates, and real incomes are all unchanged. It follows that the change dA^k in assets in each country must equal its share ω^k of the aggregate increase dB in asset supply, so that $d\text{nfa}^k = dA^k - dB^k = \omega^k dB - dB^k$. It also follows that real incomes must change by the same proportion everywhere, and real exchange rates are unchanged (since the change in the closed economy is $dQ = 0$). The common change dr^n in real interest rate is calculated in appendix C.2 from the closed-economy aggregate model. □

Corollary 1 shows that in response to a global fiscal expansion, each country in the long run increases its asset holdings by the same proportional amount: the newly created assets are spread evenly, regardless of which countries issued the debt. This is because the long-run real interest rate r is equalized across all countries—and in the symmetric calibration, a uniform increase in r leads to a uniform expansion in long-run assets. The



Note: Bars indicate predictions from corollary 1: long-run nfas in the symmetric model are equal to the demeaned excess fiscal deficit. Black dots indicate the long-run NFAs in our quantitative model of section 6.

Figure 9: Long-run NFAs in quantitative model vs. predictions from proposition 1

twin deficit result in proposition 1 now characterizes *deviations* from the world average: an increase in a country's debt over and above its share of the world's debt leads to a one-for-one deterioration in its long-run NFA.

To apply this result in practice, consider the recent Covid fiscal expansion. As we will document in more detail in section 5, this expansion was very unequal, with countries like the United States expanding their deficits, relative to pre-Covid GDP, by much more than countries like Denmark. Applying corollary 1 we can obtain the implied long-run change in NFAs in each country by taking its cumulative increase in deficits relative to the world average. These predictions are given by the bars in figure 9. For instance, because it had a very limited increase in public debt, Denmark's net foreign asset position is projected to increase by around 11 percentage points of GDP, while the U.S.'s NFA is projected to deteriorate by around 2 percentage points. Note that, for most large countries, these long-run NFAs are relatively modest, because the fiscal expansions tended to be large in all of these countries.

At the same time, the world real interest rate must increase by enough to clear the world asset market in the long run, with the first-order effect given by (51). The first column of table 2 reports numbers for our symmetric model in the context of the recent Covid fiscal expansion. The average cumulative deficit (dB) is 12% of GDP, which is a proportional change of $d \log B = 14\%$ given an initial level of 82%. The interest semi-elasticity of asset demand in the model is around 21, implying a first-order effect on interest rates

		Symmetric countries	Quantitative model
Increase in debt (% of initial)	$d \log B$	14.5%	14.5%
Interest semi-elasticity of savings	$\frac{d \log a}{dr}$	21.3	21.3
Tax adjustment (with $\sigma = 1$)	$a(r)\left(1 + \frac{1}{1-G/Y}\frac{1}{1+\phi}\right)$	1.3	1.3
First-order approximation	dr^n	72bp	72bp
Actual change	$r - r^n$	71bp	68bp

Note: This table implements equation (51) and compares the effect to solution in the full quantitative model of section 6 with asymmetric countries. Semi-elasticities and interest rate effects are annualized.

Table 2: Effect on the long-run world interest rate from the world fiscal shock

of 72 basis points—very close to the true, nonlinear effect in the model.[23]

4.3 Application: transitional dynamics

We now assume that countries announce an entire fiscal expansion path $\left\{dB_t^k\right\}$, eventually settling at $dB^k = \lim_{t\to\infty} dB_t^k$. We also allow for an arbitrary path of changes to government spending $\{dG_t^k\}$ in each country, but continue to assume steady-state $r = 0$ for simplicity.

In section 3, we had simple analytical results for impulse responses to fiscal shocks in the small open economy, assuming that monetary policy follows a constant-r rule. By proposition 4, these results also describe demeaned impulse responses in the world economy, assuming that demeaned r is constant at zero—i.e. that countries across the world maintain the same path of real interest rates in response to the shock, perhaps motivated by a desire to avoid real exchange rate movements.

At the aggregate world level, the response of output is the same as in the standard closed-economy case, with an intertemporal Keynesian cross as described in Auclert et al. (2018), augmented with a consumption response $Z\mathbf{M}^r d\mathbf{r}$ to the average real interest rate change (which can come from an arbitrary monetary rule).[24]

[23] There is reason to believe that this effect on the world interest rate may be a little high. First, while the semi-elasticity of asset demand is similar to the one calculated by Auclert, Malmberg, Martenet and Rognlie (2021b) using a realistic life-cycle model, our model underestimates total assets since it ignores other components of wealth beyond public debt: hence, in practice, an increase of world public debt of 12% as a share of GDP represents a much smaller proportional increase in assets. Second, the literature review in Mian, Straub and Sufi (2022) suggests that a 10% increase in public debt raises the world interest rate only by around 20bp.

[24] Here, $M_{t,s}^r \equiv \frac{\partial \mathcal{C}_t}{\partial r_s}(\{1, r\})$, where $\mathcal{C}$ is the consumption function defined in section 2. The full result for $d\mathbf{Y}$ in the corollary can be derived from (74), substituting $\alpha = 0$ for the closed economy. Note that we cannot write $d\mathbf{Y}$ as an infinite series as in (44), because with $\alpha = 0$ it is no longer guaranteed that this series will converge.

We summarize these observations in the following corollary.

Corollary 2. *If monetary policy implements the same path* $d\mathbf{r}$ *in all countries, then the demeaned impulses in each country are given by equations (44)–(46), in response to the demeaned shocks* $d\widetilde{\mathbf{FD}}^k$ *and* $d\tilde{\mathbf{G}}^k$ *to deficits and government spending. More generally, for any monetary rules in each country, the aggregate response is characterized by the equations* $d\boldsymbol{Y} = d\boldsymbol{G} + \boldsymbol{M}(d\boldsymbol{PD} - d\mathbf{G}) + Z\mathbf{M}^r d\mathbf{r} + \boldsymbol{M}d\boldsymbol{Y}$ *and* $d\boldsymbol{PS} = d\boldsymbol{FD}$*, where* $d\mathbf{r}$ *is the average world real interest rate.*

Applying the first part of corollary 2 to the simple fiscal experiment we contemplated in section 3—where each country permanently increases its debt by some amount—gives the following simple prediction for a cross-sectional regression.

Corollary 3. *Consider the data* $\left(d\boldsymbol{A}^k, d\mathbf{nfa}^k\right)$ *generated by the model hit by a one-time permanent shock to debt in each country,* $d\boldsymbol{B}^k = dB^k\mathbf{1}$*, assuming that all countries have a common monetary response* $d\mathbf{r}$*. Then, a regression of* dA_t^k *on* dB^k *delivers the time path in the bottom right panel of figure 4, and a regression of* $d\text{nfa}_t^k$ *on* dB^k *delivers the time path in the bottom center panel of figure 4.*

In the next section, we take corollary 3 directly to the data.

It is worth noting that proposition 4 also applies for other specifications of monetary policy, such as Taylor rules, or rules that replicate the natural flexible-wage allocation. The impulse responses of our small open economy model in section 3 under these rules will continue to give, by proposition 4, demeaned impulse responses in the world economy, with cross-sectional predictions as in corollary 3. For our dependent variables of interest (dA_t^k and $d\text{nfa}_t^k$), however, figure 6 suggests little effect from alternative monetary rules: the current account response, and therefore $d\text{nfa}_t^k$ and dA_t^k, is nearly identical for the three.

A similar generalization also applies for other shocks, and other variables of interest. For instance, we could look at the cross-sectional impact of deficit-financed government spending shocks on output, and compare to cross-sectional multipliers estimated in the data as in Nakamura and Steinsson (2014) and Chodorow-Reich (2019).[25]

5 Excess savings and twin deficits during the pandemic

Our analysis predicts a distinctive cross-country time path of excess savings and current accounts in response to a worldwide fiscal expansion. In this section, we test this prediction using the Covid pandemic as a natural experiment. While this is not an ideal

[25] If, as in these papers, the setting is one of a currency union where monetary policy follows a common *nominal* interest rate path, the analog to corollaries 2 and 3 states that cross-sectional fiscal multipliers are equal to multipliers in a small open economy with a constant *nominal* interest rate rule $i_t \equiv i$.

experiment because the pandemic was a shock in itself, it is nevertheless a promising episode to study the causal effect in our model, because the fiscal policy response to the pandemic was largely unrelated to the size of the pandemic shock across countries.[26]

We are specifically interested in testing the predictions of corollary 3, which suggests running a simple regression. To do this, we first construct the empirical counterparts of the $d\boldsymbol{A}^k$, $d\mathbf{nfa}^k$, and $d\boldsymbol{B}^k$ variables for a set of 26 advanced economies. We then run the regression implied by corollary 3 directly in these data, and show that the empirical regression results support our model predictions. We conclude by discussing potential sources of bias in our regression, and how we address these.

5.1 Data

We focus on advanced economies, following the IMF's definition. These economies are a natural starting point for our analysis because they constitute a large and highly financially integrated part of the world.

For advanced economy k, we collect data on (net) private saving PS_t^k, (net) investment I_t^k, the current account CA_t^k, the fiscal deficit FD_t^k, and GDP Y_t^k over the period 2014Q1–2021Q2. Private saving (respectively net investment) is constructed by subtracting depreciation from gross private saving (respectively gross investment) in the OECD Quarterly Sector Accounts; the other three variables are from the IMF International Financial Statistics database. 28 advanced countries have both current account and fiscal deficit data for the entire period. We exclude Ireland and Norway, whose current accounts are known to be heavily influenced by tax haven flows, and oil and natural gas prices, respectively. This determines our baseline set of 26 countries. We also define a reduced set of 17 countries that also have private saving data and investment data, so that the full balance of payments is available.[27] Appendix D lists all the countries in our baseline and reduced sample, and provides more details about the variables we use. We refer to the set of remaining 16 advanced economies in the reduced sample, excluding the U.S., as the "Rest of the World".

To test corollary 3, we need to construct the empirical analogues of $d\mathbf{A}^k, d\text{nfa}^k$ and $d\mathbf{B}^k$. We do this as follows. We define "excess private savings" as the accumulated stock of assets from private saving above the pre-Covid trend. That is, taking $t = 0$ to be

[26] An alternative approach to testing the model would be to study the dynamic effect on worldwide savings and current accounts after an identified deficit-financed tax shock in one country, in the spirit of Guajardo et al. (2014).

[27] Countries for which we are missing saving or investment data make up a relatively small fraction of advanced economy GDP: Belgium, Cyprus, Estonia, Iceland, Latvia, Lithuania, Luxembourg, Malta, and Slovakia.

2020Q1, we define for any quarter $t \geq 1$:

$$\text{Excess Private Savings}_t^k \equiv \sum_{s=1}^{t} \left(\frac{PS_s^k}{Y_0^k \left(1+\overline{g^k}\right)^s} - \overline{\left(\frac{PS}{Y}\right)^k} \right) \tag{52}$$

where $g_t^k \equiv \frac{Y_{t+1}^k}{Y_t} - 1$ is nominal GDP growth, and bars denote the 5 year pre-pandemic average (2015Q2-2020Q1).[28] We then define cumulative "excess current account surpluses" and "excess fiscal deficits" in an exactly analogous way. These three excess metrics are natural counterparts of $dA_t^k, d\text{nfa}_t^k$ and dB_t^k respectively, because they capture the additional stock of private wealth, the additional net foreign asset position, and the additional public debt, all relative to potential GDP, that countries have incurred up until quarter t, relative to a baseline in which the corresponding flows had remained at their average level.[29] We then verify that our fiscal deficit measure lines up well with an independent measure of the fiscal response to Covid by the IMF.[30] Finally, we analogously construct "excess capital accumulation" by cumulating net investment. If we enriched our model with capital, this would be the counterpart of the capital stock in each country.

The balance of payments identity relates the four excess metrics we construct in a natural way. In each country k, modulo the statistical discrepancy, the fiscal deficit must be equal to private savings, net of the current account and investment:

$$FD_t^k = PS_t^k - CA_t^k - I_t^k \tag{53}$$

Since this equation holds in every time period, it also holds for the cumulative measures we construct at each t. Hence, equation (53) provides us with a natural way of visualizing our data. Figure 10 performs this exercise for the U.S. and the Rest of the World: at each quarter t, it shows how much of the fiscal deficit up to that date was empirically accounted for by private saving, investment and the current account. We find that private saving accounted for the most, that current account deficits are smaller and more delayed,

[28]We rebase the level of private savings using potential GDP $Y_0^k \left(1+\overline{g^k}\right)^s$ rather than actual GDP Y_s^k to avoid the mechanical effect of the recession on the savings-to-GDP ratio.

[29]While all three stocks in principle could be measured directly, in practice measured wealth-to-GDP and NFA-to-GDP ratios are heavily influenced by valuation effects (Saez and Zucman 2016, Gourinchas and Rey 2007, Atkeson, Heathcote and Perri 2022). Our metric of excess savings corresponds more directly to the increase in wealth that resulted from additional saving by private agents, rather than from changes in the prices of the assets they held.

[30]Source "Fiscal Policies Database in Response to COVID-19", entry "Additional spending or foregone revenues in non-health sector, as % of GDP, covering measures for implementation in 2020, 2021, and beyond."

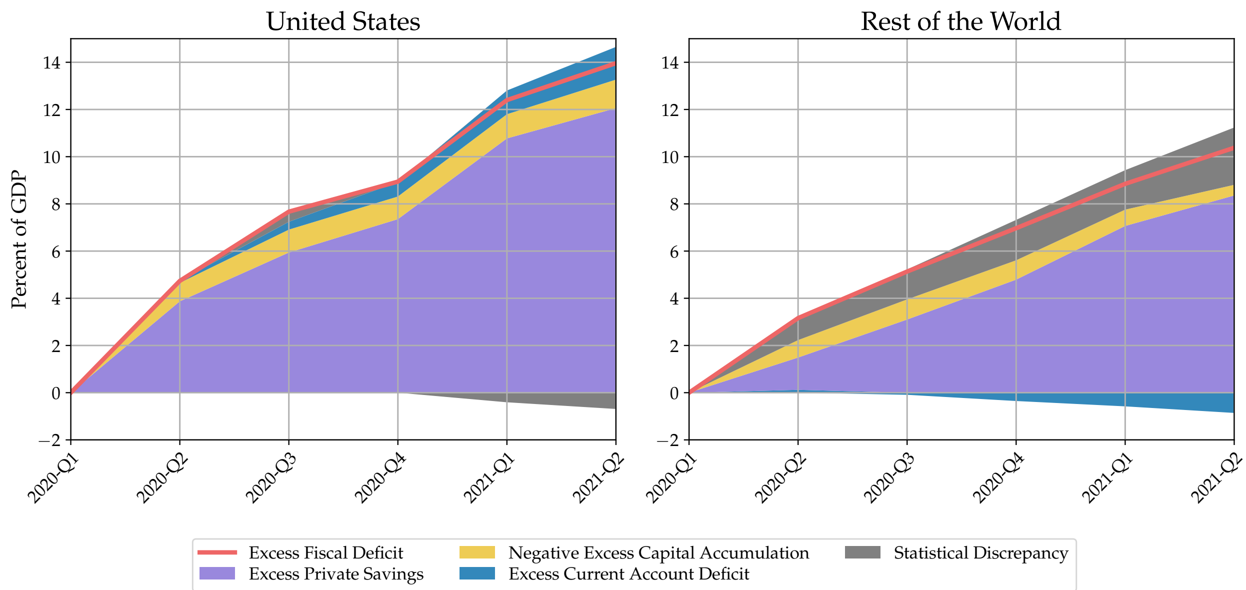


Figure 10: Accounting for fiscal deficits in the United States and the Rest of the World

and that investment moved little.[31] These patterns are qualitatively consistent with those implied by our model in response to a shock to fiscal deficits that is larger in the U.S. than the rest of the world. We next show that they are also quantitatively consistent with the model's predictions given the excess fiscal deficits we measure.

5.2 Testing the symmetric model

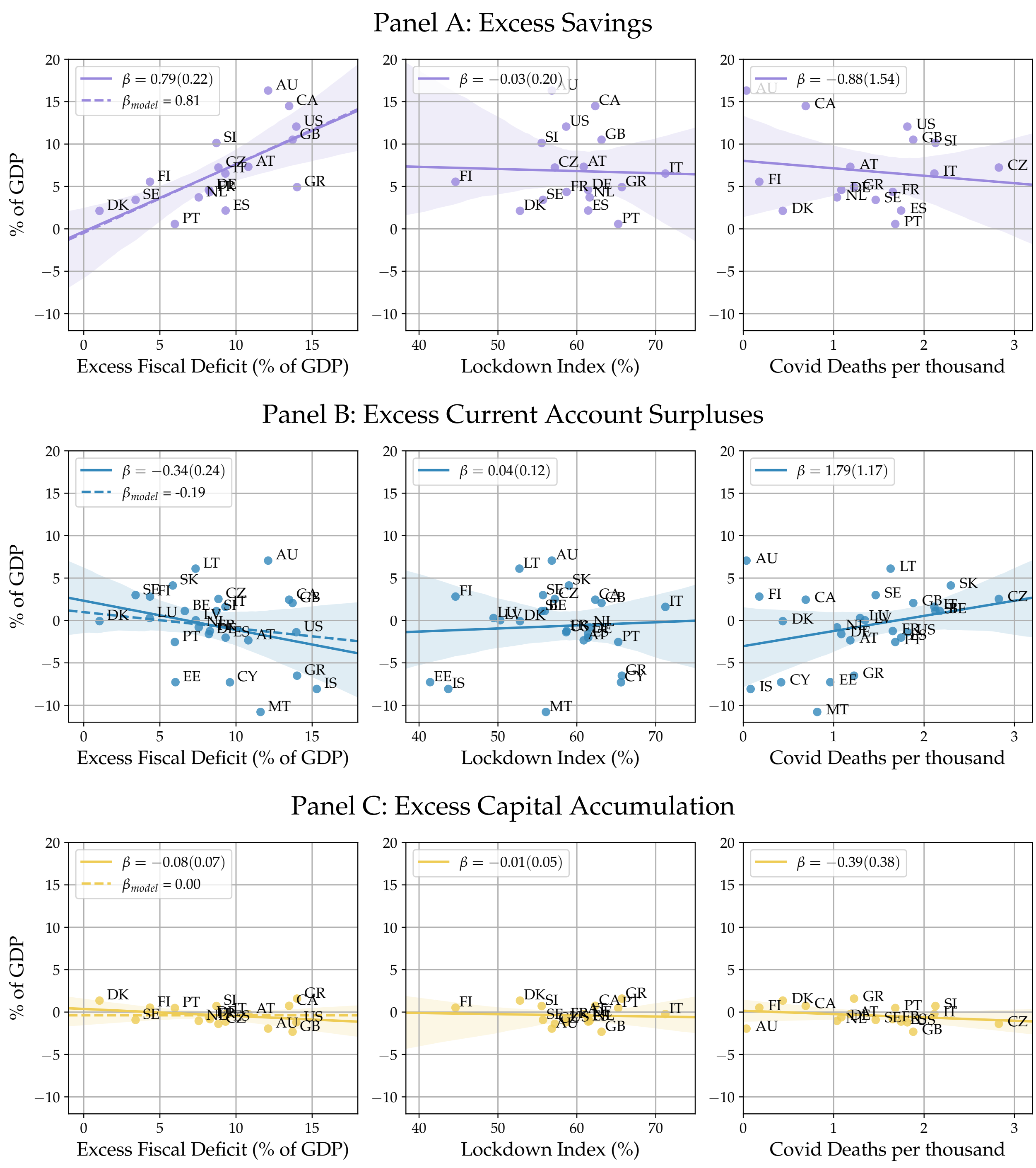
We start by running the simple regression implied by corollary 3. Specifically, we regress excess savings, current account surpluses, and capital accumulation on excess fiscal deficits after t quarters; for instance, we run in the cross section of countries k :

$$\text{Excess Private Savings}_t^k = \alpha^k + \beta_t \text{Excess Fiscal Deficits}_t^k + \epsilon^k$$

The results as of 2021Q2 ($t = 5$) are displayed in the left column of figure 5.

The figure confirms that larger fiscal deficits are associated with larger savings and a current account deficit after 5 quarters, with limited effect on investment. In addition, it shows that the model and the data pass-through coefficients are quantitatively consistent: the point estimate on excess savings is 0.81 in the model vs 0.79 in the data, and that on current accounts is -0.19 in the model vs -0.34 in the data, although it is not precisely

[31] As appendix figure 20 shows, these patterns are broadly the same in all of the 16 "Rest of the World" countries in our sample.



Note: β indicates the regression coefficient of the y-axis on the x-axis variable. The standard error around this coefficient is in parentheses. Shaded areas correspond to 68% bootstrapped confidence intervals. The dashed lines in the left panels represent the prediction from the baseline model, with slopes for excess savings and current accounts given by the black dots of figure 4.

Figure 11: Cross-country determinants of excess savings and current accounts

estimated.[32] The dashed lines in the figure visualize this quantitative success, which is unique to our model with realistic home bias and MPCs. Without home bias, for instance, our model implies a pass-through of 0.4 on savings and -0.6 for current accounts (see figure 4), which is much too fast relative to the data.[33] In appendix figure 18, we further show that the time path of the empirical pass-through coefficients is also consistent with that predicted by the model: the savings passthrough starts close to 1 and declines over time, and the current account pass-through starts close to 0 and declines over time.

While we view the fact that the simple regression coefficients match up in the data and the model as an important success of our model, in principle, the simple regression is biased if the fiscal shock is correlated with another shock at the country level, *and* if that shock in turn has a meaningful effect on excess savings and current accounts. The main shocks that we have to worry about during this period are those related to the disruptions caused by Covid. In section 3.5, we argued that, in theory, a Covid shock alone can only have a modest effect on savings or the current account. We now show that this also appears to be the case in the data.

To this end, the middle and right columns of figure 11 rerun our simple regressions, but substituting the fiscal deficit variable with two country-level metrics of Covid intensity: a lockdown index (where 0 indicates laxest and 100 strictest) and the cumulative number of deaths per thousand individuals.[34] These graphs show that the Covid shock story has a difficult time explaining the cross-section of excess savings. The lockdown has no association with savings, with a point estimate of zero. Covid deaths correlate with the wrong sign: an increase in deaths by 2 per thousand, from the Finnish to the Italian level, reduces excess savings by 2%. Similarly, lockdowns and Covid deaths have a difficult time explaining the cross-section of current accounts: the point estimates are positive but insignificant.[35]

This limited empirical association between measures of the Covid shock and excess savings or current accounts suggest that controlling for the size of the Covid shock directly should not change our main regression coefficients much. Appendix figure 19 veri-

[32]Given (53), the coefficients on private savings, minus those on capital accumulation and current accounts, must be 1. This is not exactly true in figure 11 because we have more countries with data on current accounts and because of the statistical discrepancy in the data.

[33]In a Ricardian model, the pass-through is 1 for savings and 0 for current accounts. While this is not technically rejected by the macro data in figure 11, this model is clearly inconsistent with the micro MPC and spending down evidence that motivate this paper.

[34]The lockdown index is "a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100". Covid deaths per thousand are cumulated between 2020Q1 and 2021Q2. Source: Our World in Data stringency index and Covid deaths.

[35]Investment also has very limited association with either fiscal deficits or Covid severity. This suggests that it is not a limitation for our model to abstract away from it altogether.

fies that this is in fact the case. The next section provides a model-based way of extracting the magnitude of the Covid shock in each country.

6 Quantitative model

In this section, we turn to a quantitative version of our model that relaxes the main limitations of our analysis so far. First, we relax the symmetry assumption, calibrating to openness and fiscal policy data for 26 countries. Second, we relax the assumption that the fiscal policy shock was a one-off shock in 2020Q1, instead feeding in the realized time path of fiscal deficits since that date. Finally, and most importantly, we explicitly add a Covid shock to each country, inferring the magnitude of this shock from the realized level of consumption in each country, similar to Gourinchas et al. (2021).

6.1 Calibration, shocks, and solution method

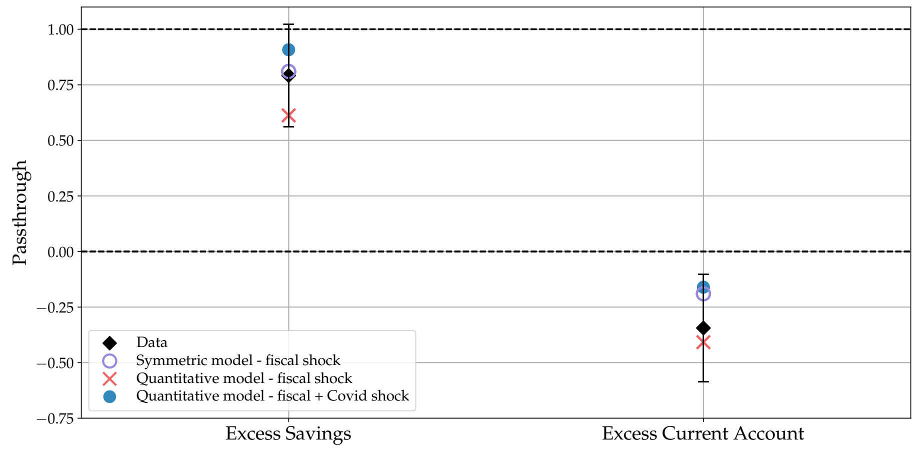
Instead of assuming symmetric countries, we now calibrate each economy in order to hit its own degree of openness α^k, government debt B^k/Y^k, and spending G^k/Y^k. Appendix E.1 provides details of these calibration targets.

While the specification of monetary policy was unimportant for our cross-country pass-through predictions, it becomes important in these simulations. We assume a reasonable specification of monetary policy, where the authority in each country follows a Taylor rule,

$$i_t = r_t^* + \phi_\pi \pi_t$$

with r_t^* phasing in the transition between the initial natural rate of interest and the long-run natural rate. Our assumption here is that monetary authorities are recognizing the pressure of fiscal policy on interest rates and acting accordingly to avoid long-run inflationary pressure. In particular, this monetary policy rule ensures that the economy reaches the natural allocation in the long run, as in the assumption of corollary 1.

Our model allows us to recognize the presence of two shocks in each country: a fiscal shock and a Covid shock. Our measure of the fiscal shock dB_t^k in country k is the realized time paths of excess fiscal deficits computed in section 5. Our measure of the Covid shock in each country is inferred from the realized time path of consumption, as follows. We simulate the counterfactual effect of the fiscal shock on consumption in each country. This effect is positive everywhere, and larger in countries with bigger fiscal interventions, reflecting the fact that fiscal policy supported spending. We then subtract this effect from the actual consumption path in each country, and find the time path of Covid shocks



Note: "Data" corresponds to our cross-country regressions on excess fiscal deficits as of 2021Q2 ($t = 5$), with 68% confidence intervals. "Model" corresponds to the same regression coefficients in each of the three models we consider.

Figure 12: pass-through regression coefficients in the data and the model

in all 26 countries that rationalizes these paths. Specifically, we assume that the Covid shock is an AR(1) discount factor shock as discussed in section 3.5, with country-specific magnitude σ^k and a common persistence ρ. We then pick $\left(\sigma^k, \rho\right)$ to hit consumption in each country perfectly in 2020Q1 and to minimize the square distance of the time path of consumption in the model and the data afterwards. Appendix figure 21 visualizes this procedure, showing the actual time path of consumption in each country, the effect implied by the fiscal shocks, and the effect implied by the Covid shocks.

Because the countries are no longer symmetric, we can no longer rely on our results from section 4 to derive the world allocation and instead must solve for the 26-country allocation simultaneously. We instead use a novel approach to do this, adapting the ideas of Auclert et al. (2021a), which we discuss further in appendix E.2.

6.2 Testing the quantitative model

Figure 12 compares the pass-through coefficients of fiscal deficits on excess savings and current accounts in the data relative to our model, both at quarter 5. The data line corresponds to empirical regression in figure 11, together with 68% confidence intervals. The purple circle labeled "symmetric model - fiscal shock" corresponds to the prediction from the symmetric model, per corollary 3 and the black dots in figure 4.

The red cross in the figure, labelled "quantitative model - fiscal shock", shows that considering a non-symmetric world and the empirical time path for fiscal deficits does not significantly change these results. The main effect stems from the fact that the world as a whole is more open than the U.S., which we used to calibrate our baseline model. As

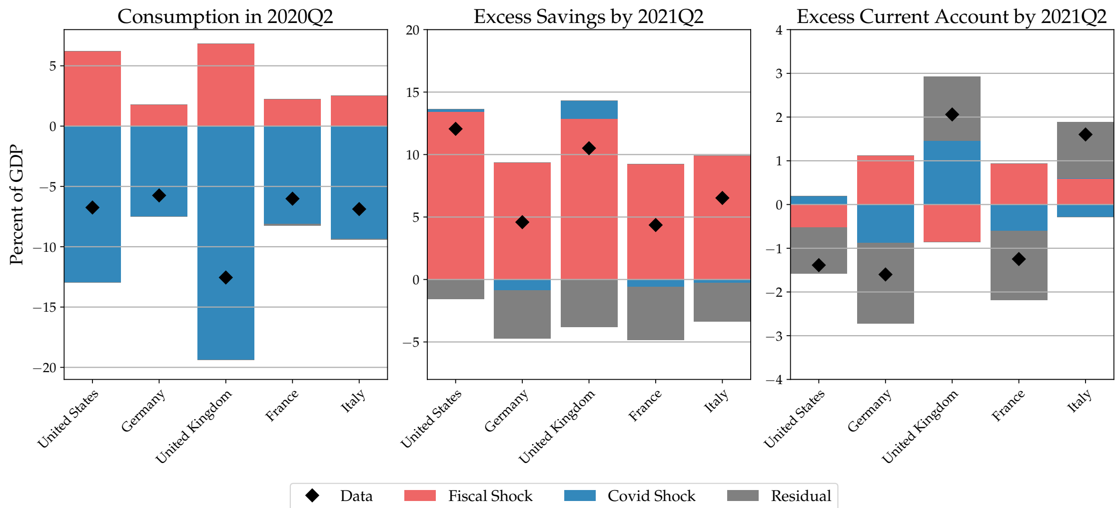


Figure 13: Share of consumption, excess savings and current accounts explained by each shock

a consequence, the model converges to its long-run steady state faster: by quarter 5, the pass-through is closer to 0 for savings and closer to -1 for current accounts.

The blue dot in the figure, labelled "quantitative model - fiscal + Covid shock", shows that considering country-specific Covid shocks still keeps our two regression coefficients within the 68% error band. Our procedure infers that countries with larger fiscal shocks also experienced a larger Covid shock, consistent with the view that the fiscal shock was in part a response to the Covid shock. Given our discussion in section 3.5, a larger Covid shock increases savings and creates a current account surplus. The net effect is to push up the regression coefficients on both excess savings and the current account, back towards the top of the error band. Overall, these three versions of the model are consistent with the data, while a model without home bias or high MPCs is not.[36]

We next turn to the model's ability to explain the overall variation in the data. For the largest 5 countries by GDP in our sample, figure 13 considers how much of consumption in 2020Q2, excess savings in 2021Q2, and current accounts in 2021Q2 can be explained by our model, and then splits the model contribution into the independent contribution of Covid shocks and fiscal shocks. By construction, our model can explain the level of consumption in 2020Q2 in each country: it finds that the Covid shock explains the decline in consumption everywhere, while fiscal policy boosted consumption in all countries. Turning to excess savings, which is not targeted by our procedure, the model does a very good job at explaining this outcome across countries overall, with limited role for

[36] Appendix figure 18 shows that different versions of our model still compare favorably to the data when we consider the dynamic pass-through regressions: the regression coefficients then start at 1 and decay towards those of figure 12 for savings, and they start at 0 and decay towards those of figure 12 for current accounts.

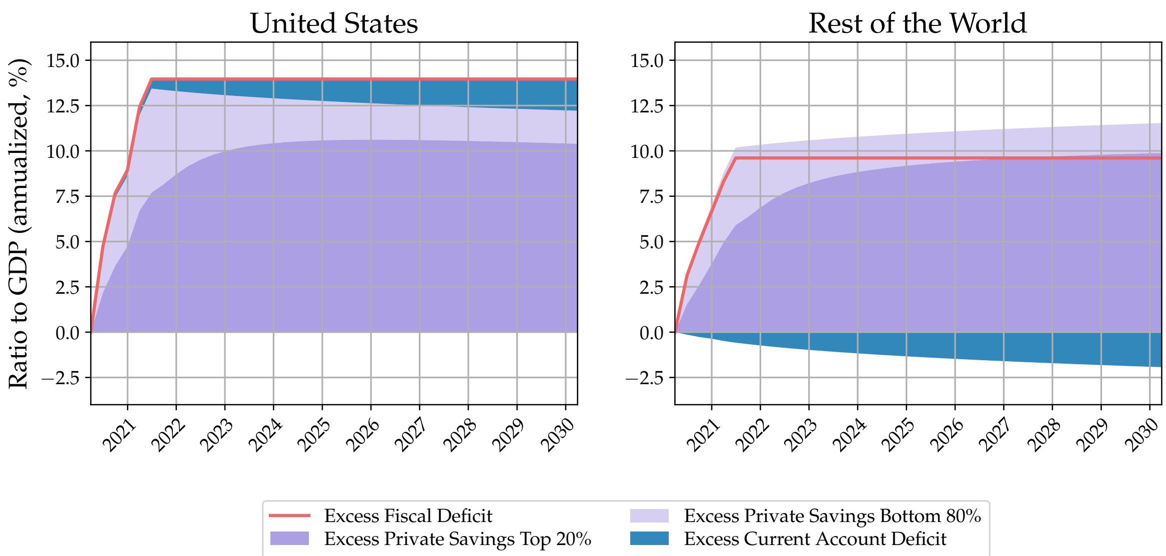


Figure 14: Excess savings and their distribution: U.S vs the rest of the world

the residual. Our key finding is that the fiscal shock explains the vast majority of excess savings in the data, with almost no role for the Covid shock. This is for two reasons. First, the fiscal shock is calibrated to the data and has a realistic pass-through to savings. Second, a Covid shock alone cannot affect savings much, as demonstrated in section 3.5.

Finally, we find that the model has limited explanatory power for current account movements. Hence, while the pass-through coefficient of fiscal deficits to current accounts has the right magnitude, there is a role for additional shocks to explain the data. Our Covid shock is one of these, but even after it is added, much of the variation in current accounts remains unexplained. We conjecture that this is for two reasons. First, most theories have a difficult time explaining empirical movements in current accounts. Second, if our theory that twin deficits take place in slow motion is correct, then fiscal deficits should in fact have limited explanatory power for current accounts over short horizons.

7 Conclusion

We show that a multi-country HANK open-economy model is consistent with the initial phases of excess savings and twin deficits that followed the Covid epidemic worldwide. Our model suggests that excess savings are here to last, but that they will be held increasingly by the world's rich, with twin deficits continuing to pool them across countries. Figure 14, which shows the empirical dynamics of asset ownership predicted by our model going forward, illustrates this conclusion.

References

Atkeson, Andrew, Jonathan Heathcote, and Fabrizio Perri, "The End of Privilege: A Reexamination of the Net Foreign Asset Position of the United States," Working Paper 29771, National Bureau of Economic Research, February 2022.

Auclert, Adrien, "Monetary Policy and the Redistribution Channel," *American Economic Review*, June 2019, *109* (6), 2333–2367.

_ , Bence Bardóczy, Matthew Rognlie, and Ludwig Straub, "Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models," *Econometrica*, 2021, *89* (5), 2375–2408.

_ , Hannes Malmberg, Frederic Martenet, and Matthew Rognlie, "Demographics, Wealth, and Global Imbalances in the Twenty-First Century," Working Paper 29161, National Bureau of Economic Research, August 2021.

_ , Matthew Rognlie, and Ludwig Straub, "The Intertemporal Keynesian Cross," Working Paper 25020, National Bureau of Economic Research, September 2018.

_ , _ , and _ , "Micro Jumps, Macro Humps: Monetary Policy and Business Cycles in an Estimated HANK Model," Working Paper 26647, National Bureau of Economic Research, January 2020.

_ , _ , Martin Souchier, and Ludwig Straub, "Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel," Working Paper 28872, National Bureau of Economic Research, May 2021.

Ball, Laurence and N. Gregory Mankiw, "What Do Budget Deficits Do?," *Proceedings of the Jackson Hole Economic Policy Symposium*, 1995, pp. 95–119.

Baqaee, David and Emmanuel Farhi, "Supply and Demand in Disaggregated Keynesian Economies with an Application to the COVID-19 Crisis," *American Economic Review*, May 2022, *112* (5), 1397–1436.

Bernheim, B. Douglas, "Budget Deficits and the Balance of Trade," *Tax Policy and the Economy*, January 1988, *2*, 1–31.

Bilbiie, Florin, Gauti Eggertsson, and Giorgio Primiceri, "US 'Excess Savings' Are Not Excessive," *voxEU column*, March 2021.

Bilbiie, Florin O., "Limited Asset Markets Participation, Monetary Policy and (inverted) Aggregate Demand Logic," *Journal of Economic Theory*, May 2008, *140* (1), 162–196.

Blanchard, Olivier, "Public Debt and Low Interest Rates," *American Economic Review*, April 2019, *109* (4), 1197–1229.

Blanchard, Olivier J., "Debt, Deficits, and Finite Horizons," *Journal of Political Economy*, April 1985, *93* (2), 223–247.

Chinn, Menzie D. and Eswar S. Prasad, "Medium-Term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Exploration," *Journal of International Economics*, January 2003, *59* (1), 47–76.

_ **and Hiro Ito**, "Current Account Balances, Financial Development and Institutions: Assaying the World "Saving Glut"," *Journal of International Money and Finance*, June 2007, *26* (4), 546–569.

Chodorow-Reich, Gabriel, "Geographic Cross-Sectional Fiscal Spending Multipliers: What Have We Learned?," *American Economic Journal: Economic Policy*, May 2019, *11* (2), 1–34.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber, "How Did U.S. Consumers Use Their Stimulus Payments?," Working Paper 27693, National Bureau of Economic Research, August 2020.

Congressional Budget Office, "The Effects of Pandemic-Related Legislation on Output," September 2020.

Corsetti, Giancarlo and Gernot J. Müller, "Twin Deficits: Squaring Theory, Evidence and Common Sense," *Economic Policy*, October 2006, *21* (48), 598–638.

de Ferra, Sergio, Kurt Mitman, and Federica Romei, "Household Heterogeneity and the Transmission of Foreign Shocks," *Journal of International Economics*, May 2020, *124*, 1–18.

Devereux, Michael B. and Charles Engel, "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange-Rate Flexibility," *Review of Economic Studies*, October 2003, *70* (4), 765–783.

European Central Bank, "The Implications of Savings Accumulated During the Pandemic for the Global Economic Outlook, prepared by Maria Grazia Attinasi, Alina Bobasu and Ana-Simona Manu," *ECB Economic Bulletin*, September 2021, *5/2021.*

Farhi, Emmanuel and Iván Werning, "Chapter 31 - Fiscal Multipliers: Liquidity Traps and Currency Unions," in Harald Uhlig and John B. Taylor, eds., *Handbook of Macroeconomics*, Vol. 2, Elsevier, 2016, pp. 2417–2492.

Feldstein, Martin, "The Dollar and the Trade Deficit in the 1980s: A Personal View," Working Paper 4325, National Bureau of Economic Research, April 1993.

Feyrer, James and Jay Shambaugh, "Global Savings and Global Investment: The Transmission of Identified Fiscal Shocks," *American Economic Journal: Economic Policy*, May 2012, *4* (2), 95–114.

Frenkel, Jacob A. and Assaf Razin, "Fiscal Policies in the World Economy," *Journal of Political Economy*, June 1986, *94* (3, Part 1), 564–594.

Galí, Jordi and Tommaso Monacelli, "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *Review of Economic Studies*, July 2005, *72* (3), 707–734.

_ , J. David López-Salido, and Javier Vallés, "Understanding the Effects of Government Spending on Consumption," *Journal of the European Economic Association*, 2007, *5* (1), 227–270.

Ganong, Peter, Fiona Greig, Max Liebeskind, Pascal Noel, Daniel M. Sullivan, and Joseph Vavra, "Spending and Job Search Impacts of Expanded Unemployment Benefits: Evidence from Administrative Micro Data," Working Paper 3784008, Social Science Research Network, February 2021.

Ghironi, Fabio, "Macroeconomic Interdependence Under Incomplete Markets," *Journal of International Economics*, December 2006, *70* (2), 428–450.

Goldman Sachs, "The Boost From Pent-Up Savings, by Sid Bhushan and Daan Struyven," *Global Economics Analyst*, July 2021.

Gopinath, Gita and Oleg Itskhoki, "Dominant Currency Paradigm: A Review," Working Paper 29556, National Bureau of Economic Research, December 2021.

_ , Emine Boz, Camila Casas, Federico J. Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller, "Dominant Currency Paradigm," *American Economic Review*, March 2020, *110* (3), 677–719.

Gourinchas, Pierre-Olivier and Hélène Rey, "International Financial Adjustment," *Journal of Political Economy*, August 2007, *115* (4), 665–703.

—, Şebnem Kalemli-Özcan, Veronika Penciakova, and Nick Sander, "Fiscal Policy in the Age of COVID: Does it 'Get in all of the Cracks?'," Working Paper 29293, National Bureau of Economic Research, September 2021.

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori, "Expansionary Austerity? International Evidence," *Journal of the European Economic Association*, August 2014, *12* (4), 949–968.

Guerrieri, Veronica, Guido Lorenzoni, Ludwig Straub, and Iván Werning, "Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages?," *American Economic Review*, May 2022, *112* (5), 1437–1474.

Guo, Xing, Pablo Ottonello, and Diego Perez, "Monetary Policy and Redistribution in Open Economies," Working Paper 28213, National Bureau of Economic Research, March 2021.

Hagedorn, Marcus, Iourii Manovskii, and Kurt Mitman, "The Fiscal Multiplier," Working Paper 25571, National Bureau of Economic Research, February 2019.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante, "Optimal Tax Progressivity: An Analytical Framework," *Quarterly Journal of Economics*, 2017, *132* (4), 1693–1754.

House, Christopher L., Christian Proebsting, and Linda L. Tesar, "Austerity in the Aftermath of the Great Recession," *Journal of Monetary Economics*, November 2020, *115*, 37–63.

IMF, *Fiscal Monitor: Strengthening the Credibility of Public Finances*, Washington, D.C.: International Monetary Fund, October 2021.

IMF Fiscal Affairs Department, "Fiscal Monitor Database of Country Fiscal Measures in Response to the COVID-19 Pandemic," October 2021.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante, "Monetary Policy According to HANK," *American Economic Review*, March 2018, *108* (3), 697–743.

Kim, Soyoung and Nouriel Roubini, "Twin Deficit or Twin Divergence? Fiscal Policy, Current Account, and Real Exchange Rate in the U.S.," *Journal of International Economics*, March 2008, *74* (2), 362–383.

Kumhof, Michael and Douglas Laxton, "Fiscal Deficits and Current Account Deficits," *Journal of Economic Dynamics and Control*, October 2013, *37* (10), 2062–2082.

McKay, Alisdair and Ricardo Reis, "The Role of Automatic Stabilizers in the U.S. Business Cycle," *Econometrica*, January 2016, *84* (1), 141–194.

_ , Emi Nakamura, and Jón Steinsson, "The Power of Forward Guidance Revisited," *American Economic Review*, October 2016, *106* (10), 3133–3158.

Mian, Atif R., Ludwig Straub, and Amir Sufi, "A Goldilocks Theory of Fiscal Deficits," Working Paper 29707, National Bureau of Economic Research, January 2022.

Nakamura, Emi and Jón Steinsson, "Fiscal Stimulus in a Monetary Union: Evidence from US Regions," *American Economic Review*, March 2014, *104* (3), 753–792.

Oh, Hyunseung and Ricardo Reis, "Targeted Transfers and the Fiscal Response to the Great Recession," *Journal of Monetary Economics*, December 2012, *59, Supplement*, S50–S64.

Oskolkov, Aleksei, "Exchange Rate Policy and Heterogeneity in Small Open Economies," *Manuscript*, March 2021.

Parker, Jonathan A., Jake Schild, Laura Erhard, and David Johnson, "Household Spending Responses to the Economic Impact Payments of 2020: Evidence from the Consumer Expenditure Survey," Working Paper 29648, National Bureau of Economic Research, January 2022.

Saez, Emmanuel and Gabriel Zucman, "Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data," *Quarterly Journal of Economics*, May 2016, *131* (2), 519–578.

TD Bank, "Where the Road of Excess [Saving] Leads, by Maria Solovieva," *TD Economics*, September 2021.

Werning, Iván, "Incomplete Markets and Aggregate Demand," Working Paper 21448, National Bureau of Economic Research, August 2015.

Woodford, Michael, "Simple Analytics of the Government Expenditure Multiplier," *American Economic Journal: Macroeconomics*, 2011, *3* (1), 1–35.

Zhou, Haonan, "Open Economy, Redistribution, and the Aggregate Impact of External Shocks," *Working Paper*, February 2022.

A Appendix to section 2

A.1 World demand

In each country, imports are given by (6). Therefore, the total demand *received* by country l, summing all countries k, is

$$\left(C_{Ht}^{*}\right)^{l}=\omega^{l}\cdot\left(\sum_{k=1}^{K}\alpha^{k}\left(\frac{P_{lt}^{k}}{P_{Wt}^{k}}\right)^{-\gamma}\left(\frac{P_{Wt}^{k}}{P_{t}^{k}}\right)^{-\eta}C_{t}^{k}\right) \tag{54}$$

Using the law of one price $P_{lt}^{k}=\frac{\mathcal{E}_{t}^{k}}{\mathcal{E}_{t}^{l}}P_{Ht}^{l}$, which for country k reads $P_{Wt}^{k}=\mathcal{E}_{t}^{k}$ (see (11)), and the definition of the real exchange rate (12), which for country k reads $Q_{t}^{k}=\frac{\mathcal{E}_{t}^{k}}{P_{t}^{k}}$, we have:

$$\begin{aligned}
\left(C_{Ht}^{*}\right)^{l} &= \omega^{l}\cdot\sum_{k=1}^{K}\alpha^{k}\left(\frac{P_{Ht}^{l}}{\mathcal{E}_{t}^{l}}\right)^{-\gamma}\left(\frac{\mathcal{E}_{t}^{k}}{P_{t}^{k}}\right)^{-\eta}C_{t}^{k}\\
&= \omega^{l}\cdot\left(\frac{P_{Ht}^{l}}{\mathcal{E}_{t}^{l}}\right)^{-\gamma}\sum_{k=1}^{K}\alpha^{k}\left(Q_{t}^{k}\right)^{-\eta}C_{t}^{k}\\
&= \omega^{l}\cdot\left(\frac{P_{Ht}^{l}}{P_{Wt}^{l}}\right)^{-\gamma}C_{t}^{*}
\end{aligned}$$

where we have defined world import demand as $C_{t}^{*}\equiv\sum_{k=1}^{K}\alpha^{k}\left(Q_{t}^{k}\right)^{-\eta}C_{t}^{k}$. This gives equations (20) and (21).

A.2 Deriving the current account equation

Start from the aggregate budget constraint (37) and use the market clearing condition (27) at t and $t-1$ to find:

$$\begin{aligned}
C_{t}+B_{t}+\mathrm{nfa}_{t} &= \left(1+r_{t-1}\right)A_{t-1}+Z_{t}\\
&= \left(1+r_{t-1}\right)B_{t-1}+\left(1+r_{t-1}\right)\mathrm{nfa}_{t-1}+Z_{t}
\end{aligned}$$

Use the government budget constraint (14) to obtain:

$$C_{t}+\frac{P_{Ht}}{P_{t}}G_{t}+\mathrm{nfa}_{t}=\left(1+r_{t-1}\right)\mathrm{nfa}_{t-1}+Z_{t}+\frac{P_{Ht}}{P_{t}}T_{t}$$

Using the definition of post-tax income (16), we obtain:

$$C_t + \frac{P_{Ht}}{P_t} G_t + \text{nfa}_t = (1 + r_{t-1}) \, \text{nfa}_{t-1} + \frac{P_{Ht}}{P_t} Y_t$$

Let the trade deficit be defined as in (28). The net foreign asset position evolves as:

$$\text{nfa}_t = (1 + r_{t-1}) \, \text{nfa}_{t-1} - TD_t$$

In a model with valuation effects on the NFA, there would be an additional term $\left(r_t^p - r_{t-1}\right) A_{t-1}$ on the right-hand side of this expression. We obtain the relationship between the current account and the trade deficit:

$$CA_t \equiv \text{nfa}_t - \text{nfa}_{t-1} = r_{t-1} \text{nfa}_{t-1} - TD_t$$

which is equation (29). Observe, moreover, that

$$\begin{aligned} TD_t &= \frac{P_{Ht}}{P_t} C_{Ht} + \frac{P_{Wt}}{P_t} C_{Wt} - \frac{P_{Ht}}{P_t} \left(C_{Ht} + C_{Ht}^* \right) \\ &= \frac{P_{Wt}}{P_t} C_{Wt} - \frac{P_{Ht}}{P_t} C_{Ht}^* \end{aligned} \tag{55}$$

that is, it is the difference between the value of imports $\frac{P_{Wt}}{P_t} C_{Wt}$ and exports $\frac{P_{Ht}}{P_t} C_{Ht}^*$.

A.3 Walras's law for the world

In this appendix, we show that the world export market clearing condition (30) is equivalent to a world goods market condition and a world asset market clearing condition. Start from country-level goods market clearing,

$$Y_t^k - G_t^k = \left(1 - \alpha^k\right) \left(\frac{P_{Ht}^k}{P_t^k} \right)^{-\eta} C_t^k + \omega^k \cdot \left(\frac{P_{Ht}^k}{\mathcal{E}_t^k} \right)^{-\gamma} C_t^*$$

multiply by $\frac{P_{Ht}^k}{\mathcal{E}_t^k}$ and sum,

$$\sum_k \frac{P_{Ht}^k}{\mathcal{E}_t^k} \left(Y_t^k - G_t^k \right) = \sum_k \left(1 - \alpha^k\right) \frac{P_{Ht}^k}{\mathcal{E}_t^k} \left(\frac{P_{Ht}^k}{P_t^k} \right)^{-\eta} C_t^k + \sum_k \left(\omega^k \cdot \left(\frac{P_{Ht}^k}{\mathcal{E}_t^k} \right)^{1-\gamma} \right) C_t^*$$

using the price consistency condition (31) and export market clearing (30), we find

$$\begin{aligned}
\sum_k \frac{P^k_{Ht}}{\mathcal{E}^k_t}\left(Y^k_t - G^k_t\right) &= \sum_k \left\{\left(1-\alpha^k\right)\frac{P^k_{Ht}}{\mathcal{E}^k_t}\left(\frac{P^k_{Ht}}{P^k_t}\right)^{-\eta} + \alpha^k\left(Q^k_t\right)^{-\eta}\right\} C^k_t \\
&= \sum_k \left\{\left(1-\alpha^k\right)\frac{P^k_{Ht}}{\mathcal{E}^k_t}\frac{\mathcal{E}^k_t}{P^k_t}\left(\frac{P^k_{Ht}}{P^k_t}\right)^{-\eta} + \alpha^k\left(Q^k_t\right)^{1-\eta}\right\} \frac{C^k_t}{Q^k_t} \\
&= \sum_k \left\{\left(1-\alpha^k\right)\left(\frac{P^k_{Ht}}{P^k_t}\right)^{1-\eta} + \alpha^k\left(Q^k_t\right)^{1-\eta}\right\} \frac{C^k_t}{Q^k_t} \\
&= \sum_k \frac{C^k_t}{Q^k_t}
\end{aligned}$$

where the last line follows from the definition of the price index P^k_t in each country. We therefore obtain world goods market clearing (34).

From the current account identify in each country, we have:

$$\text{nfa}^k_t = \left(1 + r^k_{t-1}\right)\text{nfa}^k_{t-1} + \frac{P^k_{Ht}}{P^k_t}\left(Y^k_t - G^k_t\right) - C^k_t$$

so

$$\frac{1}{Q^k_t}\text{nfa}^k_t = \left(1 + r^k_{t-1}\right)\frac{1}{Q^k_t}\text{nfa}^k_{t-1} + \frac{P^k_{Ht}}{\mathcal{E}^k_t}\left(Y^k_t - G^k_t\right) - \frac{P^k_t C^k_t}{\mathcal{E}^k_t}$$

But from the UIP condition in country k, we have: $\frac{1+r^k_{t-1}}{Q^k_t} = \frac{1+i^*_{t-1}}{Q^k_{t-1}}$, where i^*_t is the star interest rate, which is common across countries. Hence, NFAs *in units of the common world good* satisfy

$$\frac{\text{nfa}^k_t}{Q^k_t} = \left(1 + i^*_{t-1}\right)\frac{\text{nfa}^k_{t-1}}{Q^k_{t-1}} + \frac{P^k_{Ht}}{\mathcal{E}^k_t}\left(Y^k_t - G^k_t\right) - \frac{P^k_t C^k_t}{\mathcal{E}^k_t} \tag{56}$$

Given world goods market clearing condition (34), and initial asset market clearing $\sum \frac{\text{nfa}^k_{-1}}{Q^k_{-1}} = 0$, we therefore have at each date:

$$\sum_k \frac{\text{nfa}^k_t}{Q^k_t} = 0$$

or equivalently, given $\text{nfa}^k_t = A^k_t - B^k_t$, world asset market clearing:

$$\sum_k \frac{A^k_t}{Q^k_t} = \sum_k \frac{B^k_t}{Q^k_t} \tag{57}$$

A.4 $\alpha \to 1$ limit

In the $\alpha \to 1$ limit, the economy is perfectly open. We have the following relations:

$$
\begin{aligned}
P_t &= P_{Ft} = \mathcal{E}_t \\
Q_t &= \frac{\mathcal{E}_t}{P_t} = 1 \\
C_{Ft} &= C_t \\
C_{Ht} &= 0 \\
r_t &= r_t^*
\end{aligned}
$$

Monetary policy has no control over the real interest rate or the real exchange rate. The Fisher equation is also the UIP equation,

$$1 + i_t = (1 + r_t^*) \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}$$

so the central bank can set the *nominal* interest rate, which affects the nominal exchange rate through the standard overshooting mechanism, and therefore the price index (residents only buy foreign goods, but the country is still producing goods for the rest of the world).

Real after-tax income is now

$$Z_t = \frac{P_{Ht}}{P_t} (Y_t - T_t) = \frac{P_{Ht}}{\mathcal{E}_t} (Y_t - T_t)$$

The goods market clearing condition now reads

$$Y_t = \left(\frac{P_{Ht}}{\mathcal{E}_t} \right)^{-\gamma} C^* + G_t$$

so real income is

$$Z_t = \left(\frac{P_{Ht}}{\mathcal{E}_t} \right)^{1-\gamma} C^* + \frac{P_{Ht}}{\mathcal{E}_t} (G_t - T_t)$$

in other words, it is the sum of export income (a constant when $\gamma = 1$), plus any real value of the primary deficit.

The government budget constraint is:

$$B_t = (1 + r_{t-1}) B_{t-1} + \frac{P_{Ht}}{\mathcal{E}_t} (G_t - T_t)$$

substituting into real income, we obtain:

$$Z_t = \left(\frac{P_{Ht}}{\mathcal{E}_t}\right)^{1-\gamma} C^* + PD_t$$

Domestic price inflation is:

$$\pi_{Ht} = \kappa_w \left(\frac{v'\left(Y_t/\Theta\right) Y_t}{\frac{\epsilon_w}{\epsilon_w - 1}\left(1-\lambda\right)\Theta Z_t u'\left(C_t\left(\{r, Z_s\}\right)\right)} - 1\right) + \beta\pi_{Ht+1}$$

and net foreign asset dynamics are:

$$\begin{aligned} \text{nfa}_t - \text{nfa}_{t-1} &= r_{t-1}\text{nfa}_{t-1} + \underbrace{\frac{P_{Ht}}{\mathcal{E}_t}\left(Y_t - G_t\right) - C_t}_{NX_t} \\ &= r_{t-1}\text{nfa}_{t-1} + \left(\frac{P_{Ht}}{\mathcal{E}_t}\right)^{1-\gamma} C^* - C_{Ft}\left(\{r, Z_s\}\right) \end{aligned}$$

We consider a monetary policy that targets a constant path for the terms of trade, $\frac{P_{Ht}}{\mathcal{E}_t} = 1$. These equations show that this corresponds to the $\alpha \to 1$ limit of the economy with home bias where monetary policy sets a constant Q.

A.5 Details on the U.S. calibration

Table 3 plots moments of the distribution of wealth in the model vs the data.

% of total wealth held	Gini Coefficient	Top 50%	20%	10%	5%	1%
Data (SCF 2019)	0.85	98.5	87.4	76.5	64.9	37.2
Model (US)	0.79	99.2	84.0	63.2	42.8	13.7

Table 3: Wealth Distribution - Data vs Model

B Appendix to section 3

B.1 Proof of Proposition 1

Proof. Start from the steady state steady state version of (16),

$$Z = \frac{P_H}{P}\left(Y - T\right)$$

We also have the long-run government budget constraint (14), which at $r = 0$ just reads

$$G = T$$

Moreover, from the steady state budget constraint (37) at $r = 0$, we know that we have $C = Z$. Combining the three previous equations, we find that

$$C = Z = \frac{P_H}{P}(Y - G) \tag{58}$$

From steady state goods market clearing (26), we find:

$$Y - G = (1-\alpha)\left(\frac{P_H}{P}\right)^{-\eta} C + \omega\left(\frac{P_H}{\mathcal{E}}\right)^{-\gamma} C^* \tag{59}$$

where the two relative prices that enter are simple functions of the real exchange rate Q,

$$\frac{P_H}{P} = p_H(Q) \qquad \frac{P_H}{\mathcal{E}} = p_H^*(Q) \tag{60}$$

Multiplying (59) by $\frac{P_H}{P}$, and combining with (58), we obtain:

$$C = \frac{\omega p_H(Q)\left(p_H^*(Q)\right)^{-\gamma} C^*}{1-(1-\alpha)\left(p_H(Q)\right)^{1-\eta}} \tag{61}$$

We can also rewrite (58) as

$$Y = G + C/p_H(Q) \tag{62}$$

Finally, from (9), and noting that the natural allocation requires $\pi_w = 0$, we get after plugging in production $N = Y/\Theta$ and $C = Z$, the equation

$$\frac{Y}{\Theta}v'\left(\frac{Y}{\Theta}\right) = \frac{\epsilon_w}{\epsilon_w - 1}(1-\lambda)Cu'(C) \tag{63}$$

Equations (61), (62) and (63) determine long-run C, Y, and Q. If long-run G is unchanged from the initial steady state, then these equations tells us that long-run (C, Y, Q) also are. Then, (58) implies that Z is also unchanged, so equation (27) shows that $A(r, Z)$ is unchanged. It follows that $\Delta B + \Delta \mathrm{nfa} = 0$.

In the case where G changes, we have, log-differentiating (61)—(63),

$$
\begin{aligned}
\widehat{C} &= \frac{\chi-\alpha}{1-\alpha}\widehat{Q} \\
\widehat{Y} &= \frac{G}{Y}\widehat{G} + \left(1-\frac{G}{Y}\right)\left(\widehat{C} + \frac{\alpha}{1-\alpha}\widehat{Q}\right) \\
(1+\phi)\,\widehat{Y} &= (1-\sigma)\,\widehat{C}
\end{aligned}
$$

Solving these equations, we obtain:

$$
\begin{aligned}
\widehat{C} &= -\frac{\frac{G}{Y}}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\widehat{G} \\
\widehat{Y} &= \frac{\frac{\sigma-1}{1+\phi}\frac{G}{Y}}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\widehat{G} \\
\widehat{Q} &= -\frac{\frac{1-\alpha}{\chi-1}\frac{G}{Y}}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\widehat{G} \\
&= -\frac{1-\alpha}{\chi-1}\frac{1}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\frac{dG}{Y}
\end{aligned}
$$

From market clearing, we further have:

$$
\begin{aligned}
dB + d\text{nfa} &= a\,(r)\,dZ = a\,(r)\,dC = A\frac{dC}{C} \\
&= -A\cdot\frac{\frac{G}{Y}}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\widehat{G} \\
&= -A\cdot\frac{1}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\frac{dG}{Y}
\end{aligned}
$$

This implies:

$$
\frac{-d\text{nfa}}{dB} = 1 + \frac{A}{Y}\frac{1}{\frac{\sigma-1}{1+\phi} + \left(1-\frac{G}{Y}\right)\left(\frac{\chi+\alpha-1}{\chi-1}\right)}\frac{dG}{dB}
$$

which delivers the LRPT formula in the case where $dG \neq 0$. $\square$

B.2 Proof of Proposition 3

Here, we consider the general case where $r \neq 0$ and any monetary policy. We then specialize our results to the case of constant r monetary policy with and $r = 0$.

Preliminaries. Start from the definition of the consumer price index,

$$P_t = \left[(1-\alpha) (P_{Ht})^{1-\eta} + \alpha (P_{Wt})^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

use (11) and (12) to find

$$1 = \left[(1-\alpha) \left(\frac{P_{Ht}}{P_t} \right)^{1-\eta} + \alpha (Q_t)^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

Differentiating around a steady state with $P_H / P = Q = 1$, we find

$$d\left(\frac{P_{Ht}}{P_t} \right) = -\frac{\alpha}{1-\alpha} dQ_t \tag{64}$$

From (11) and (12), we also have

$$\frac{P_{Ht}}{P_{Wt}} = \frac{P_{Ht}}{\mathcal{E}_t} = \frac{P_{Ht}/P_t}{Q_t}$$

so we also have

$$d\left(\frac{P_{Ht}}{P_{Wt}} \right) = \frac{-1}{1-\alpha} dQ_t \tag{65}$$

Next, define the primary deficit as

$$PD_t \equiv \frac{P_{Ht}}{P_t} (G_t - T_t) \tag{66}$$

and note that, from the government budget constraint (14), we have

$$PD_t = B_t - (1 + r_{t-1}) B_{t-1} \tag{67}$$

Combining the definition of real income (16) with (66), we can write real income as:

$$Z_t \equiv \frac{P_{Ht}}{P_t} (Y_t - G_t) + PD_t \tag{68}$$

Finally, we have the following lemma.

Lemma 1. *We have that:*

$$\frac{\partial C_t}{\partial r_s}\left(\{Z,r\}\right) \;=\; Z\frac{\partial C_t}{\partial r_s}\left(\{1,r\}\right) = ZM^r_{t,s}$$

where $M^r_{t,s} \equiv \frac{\partial C_t}{\partial r_s}\left(\{1,r\}\right)$ is defined as the response of spending to interest rates when steady-state post-tax income is 1, and also

$$\frac{\partial C_t}{\partial Z_s}\left(\{Z,r\}\right) \;=\; \frac{\partial C_t}{\partial Z_s}\left(\{1,r\}\right) = M_{t,s}$$

where $M_{t,s} \equiv \frac{\partial C_t}{\partial Z_s}\left(\{1,r\}\right)$ is defined as the response of spending to income when steady-state post-tax income is 1.

Proof. Follows from the homotheticity of the consumption function $C_t\left(\{Z_s,r_s\}\right)$ in Z, in the sense that, for any $\lambda \geq 0$, we have:

$$C_t\left(\{\lambda Z_s,r_s\}\right) = \lambda C_t\left(\{Z_s,r_s\}\right) \tag{69}$$

This equation, in turn, follows from standard homotheticity arguments. □

International fiscal Keynesian cross. Differentiate (68) around the steady state with $\frac{P_H}{P} = 1$, $Y - G = C$, and $PD = -rB$ (the primary balance is a surplus large enough to pay for the interest on the debt), to find:

$$\begin{aligned} d\mathbf{Z} &= d\left(\frac{\mathbf{P_H}}{\mathbf{P}}\mathbf{Y}\right) - d\left(\frac{\mathbf{P_H}}{\mathbf{P}}\mathbf{G}\right) + d\mathbf{PD} \\ &= Cd\left(\frac{\mathbf{P_H}}{\mathbf{P}}\right) + d\mathbf{Y} - d\mathbf{G} + d\mathbf{PD} \\ &= -\frac{\alpha}{1-\alpha}Cd\mathbf{Q} + d\mathbf{Y} - d\mathbf{G} + d\mathbf{PD} \end{aligned} \tag{70}$$

Next, differentiate the aggregate consumption function $C_t\left(\{r^p_s, Z_s\}\right)$, using the fact that $r^p_s = r_s$ everywhere from (23), together with lemma 1, to find:

$$d\mathbf{C} = Z\mathbf{M}^r d\mathbf{r} + \mathbf{M}d\mathbf{Z} \tag{71}$$

Substituting (5), (20), and (11) into the goods market clearing condition (26), we obtain:

$$Y_t = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t + \omega\left(\frac{P_{Ht}}{P_{Wt}}\right)^{-\gamma} C^*_t + G_t$$

Differentiating this equation around the steady state where $\alpha C = \omega C^*$, and using (64)–(65) gives

$$\begin{aligned} dY_t &= \left(\alpha C\eta + \omega C^* \cdot \frac{\gamma}{1-\alpha}\right) dQ_t + (1-\alpha)\, dC_t + \omega dC_t^* + G_t \\ &= \alpha\left(\eta + \frac{\gamma}{1-\alpha}\right) CdQ_t + (1-\alpha)\, dC_t + \omega dC_t^* + G_t \end{aligned}$$

hence, denoting $d\mathbf{Y} = (dY_0, dY_1, \ldots)$, we have:

$$d\mathbf{Y} = \frac{\alpha}{1-\alpha}\left(\underbrace{(1-\alpha)\,\eta + \gamma}_{\chi}\right) Cd\mathbf{Q} + (1-\alpha)\, d\mathbf{C} + \omega d\mathbf{C}^* + d\mathbf{G} \tag{72}$$

where χ is the trade elasticity, also known as the Marshall-Lerner elasticity (Auclert et al. 2021c).

Collecting equations, we have:

$$\begin{aligned} d\mathbf{C} &= Z\mathbf{M}^r d\mathbf{r} - \frac{\alpha}{1-\alpha} C\mathbf{M}d\mathbf{Q} + \mathbf{M}\,(d\mathbf{Y} - d\mathbf{G} + d\mathbf{PD}) \\ d\mathbf{Y} &= \frac{\alpha}{1-\alpha}\chi Cd\mathbf{Q} + (1-\alpha)\, d\mathbf{C} + \omega d\mathbf{C}^* + d\mathbf{G} \end{aligned} \tag{73}$$

we can combine to obtain the general equation:

$$\begin{aligned} d\mathbf{Y} = &\left(\underbrace{\frac{\alpha}{1-\alpha}\chi}_{\text{exp. switching}} - \underbrace{\alpha\mathbf{M}}_{\text{real income}}\right) Cd\mathbf{Q} + \underbrace{(1-\alpha)\, Z\mathbf{M}^r d\mathbf{r}}_{\text{intertemp. substitution}} \\ &+ \underbrace{(I - (1-\alpha)\,\mathbf{M})\, d\mathbf{G} + (1-\alpha)\,\mathbf{M}d\mathbf{PD}}_{\text{fiscal impulse}} + \underbrace{\omega d\mathbf{C}^*}_{\text{export demand impulse}} \\ &+ \underbrace{(1-\alpha)\,\mathbf{M}d\mathbf{Y}}_{\text{multiplier}} \end{aligned} \tag{74}$$

moreover, the real exchange rate is related to i^* via the UIP condition:

$$d\mathbf{Q} = -\frac{\mathbf{U}}{1+r}\,(d\mathbf{r} - d\mathbf{i}^*)$$

where $\mathbf{U}$ is a matrix with 1's on and above the diagonal. Finally, combining (55) with (6) and (20), we obtain:

$$TD_t = \frac{P_{Wt}}{P_t} C_{Wt} - \frac{P_{Ht}}{P_t} C_{Ht}^* = \alpha \left(Q_t\right)^{1-\eta} C_t - \omega \left(Q_t\right) \left(\frac{P_{Ht}}{P_{Wt}}\right)^{1-\gamma} C_t^*$$

Linearizing, and using (65), we find

$$\begin{aligned} dTD_t &= \alpha C \left(1-\eta\right) dQ_t + \alpha dC_t - \omega C^* \left(dQ_t - \frac{\left(1-\gamma\right)}{1-\alpha} dQ_t\right) - \omega dC_t^* \\ &= \alpha C \left(1 - \eta - 1 + \frac{1-\gamma}{1-\alpha}\right) dQ_t + \alpha dC_t - \omega dC_t^* \\ &= \frac{\alpha}{1-\alpha} C \left(1 - \underbrace{\eta\left(1-\alpha\right) + \gamma}_{\chi}\right) dQ_t + \alpha dC_t - \omega dC_t^* \end{aligned}$$

hence

$$d\mathbf{TD} = \frac{-\alpha}{1-\alpha} C \left(\chi - 1\right) d\mathbf{Q} + \alpha d\mathbf{C} - \omega d\mathbf{C}^* \tag{75}$$

Other things equal, a depreciation worsens the trade deficit if $\chi > 1$. More local demand $d\mathbf{C}$ also worsens the trade deficit since it increases imports. An exogenous increase in foreign demand $d\mathbf{C}^*$ raises exports and lowers the trade deficit.

Constant-r monetary policy In the case of a small open economy, with $d\mathbf{i}^* = d\mathbf{C}^* = 0$, and constant-$r$ monetary policy, we have $d\mathbf{r} = d\mathbf{Q} = 0$. Then (74) specializes to

$$d\mathbf{Y} = \left(I - \left(1-\alpha\right)\mathbf{M}\right) d\mathbf{G} + \left(1-\alpha\right) \mathbf{M} d\mathbf{PD} + \left(1-\alpha\right) \mathbf{M} d\mathbf{Y} \tag{76}$$

Solving this delivers:

$$d\mathbf{Y} = d\mathbf{G} + \left(1-\alpha\right) \left(I - \left(1-\alpha\right)\mathbf{M}\right)^{-1} \mathbf{M} d\mathbf{PD} \tag{77}$$

Using this solution into (73) gives

$$\begin{aligned} d\mathbf{C} &= \mathbf{M}\left(d\mathbf{Y} - d\mathbf{G} + d\mathbf{PD}\right) \\ &= \mathbf{M}\left(I - \left(1-\alpha\right)\mathbf{M}\right)^{-1} \left(\left(1-\alpha\right)\mathbf{M} + I - \left(1-\alpha\right)\mathbf{M}\right) d\mathbf{PD} \\ &= \mathbf{M}\left(I - \left(1-\alpha\right)\mathbf{M}\right)^{-1} d\mathbf{PD} \end{aligned}$$

and using this into (75) gives the general twin deficit equation relating the *primary deficit* to the *trade deficit:*

$$d\mathbf{TD} = -\alpha \mathbf{M} \left(I - (1-\alpha) \mathbf{M} \right)^{-1} d\mathbf{PD}$$

Special case with $r = 0$. Around $r = \text{nfa} = 0$, we have from (29) that

$$d\mathbf{CA} = -d\mathbf{TD}$$

Moreover, differentiating (67) we find $dPD_t = dB_t - dB_{t-1} - Bdr_{t-1} = dFD_t - Bdr_{t-1}$. In turn, with $d\boldsymbol{r} = 0$ we obtain:

$$d\mathbf{PD} = d\mathbf{FD}$$

Plugging this into (77) gives equation (44), hence, in this case the twin deficit equation can also be written as a relationship between the *current account deficit* $-d\mathbf{CA}$ and the fiscal deficit $d\mathbf{FD}$,

$$-d\mathbf{CA} = -\alpha \mathbf{M} \left(I - (1-\alpha) \mathbf{M} \right)^{-1} d\mathbf{FD}$$

which is equation (45).

B.3 No-anticipation model

Here we describe the no-anticipation model. The the $\mathbf{M}$ matrix is given by

$$\mathbf{M}^{na} = \begin{pmatrix} M_{00} & 0 & 0 & \\ M_{01} & M_{00} & 0 & \\ M_{02} & M_{01} & M_{00} & \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \tag{78}$$

Figure 15 shows the iMPCs in this case. This would be the outcome, for instance, of adding sticky expectations to our baseline model as in Auclert, Rognlie and Straub (2020), if expectations were perfectly sticky.

Applying equations (44)–(45) to this model, we find:

$$\begin{aligned} dY_0 &= \frac{(1-\alpha) \cdot mpc}{1 - (1-\alpha)\, mpc} dB \\ dCA_0 &= -\frac{\alpha \cdot mpc}{1 - (1-\alpha)\, mpc} dB \end{aligned}$$

Now we see the exact effect of income adjustment on both GDP and the current account. Figure 16 provides the general equilibrium simulation, we see that the no-anticipation

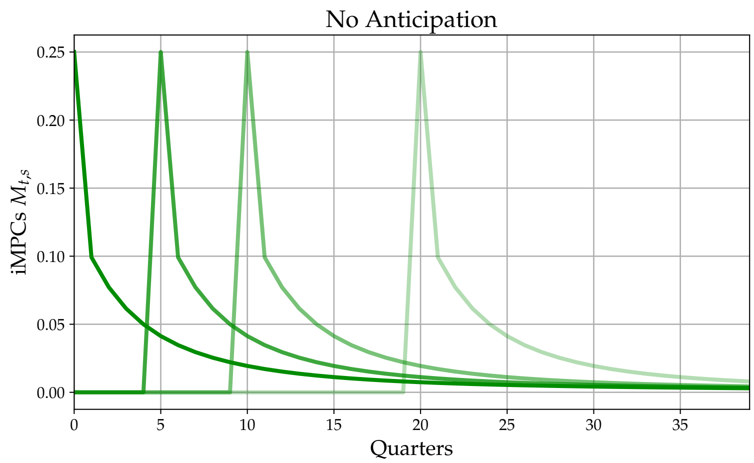


Figure 15: Intertemporal marginal propensities to consume in the no-anticipation model

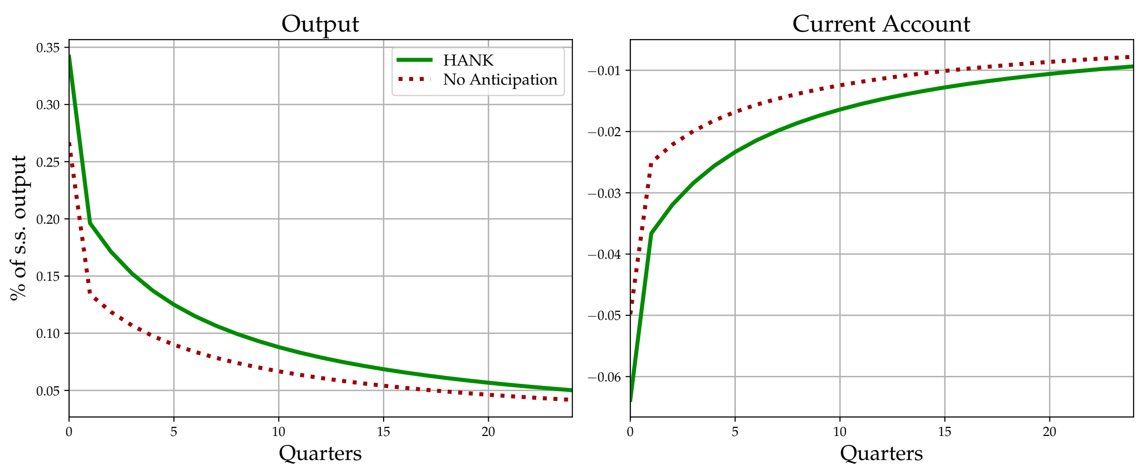


Figure 16: Impulse response to a transfer: main model vs model with $\mathbf{M}^{na}$

model has slightly lower output and current response throughout, but the time paths are otherwise similar.

B.4 Case with $r \neq 0$

Here, we revisit propositions 1–3 in the case with $r \neq 0$. The steady state result is similar, but the long-run pass-through is no longer exactly 1. With $r > 0$, the LPRT is typically above 1, as a government debt expansion leads to a reduction in post-tax income and therefore asset demand. The dynamic equations, however, are the same, provided that, in propositions 2 and 3, we replace $-d\mathbf{CA}$ with the trade deficit $d\mathbf{TD}$, and $d\mathbf{FD}$ with the primary deficit $d\mathbf{PD}$.

Long-run pass-through. We mirror the proof of Proposition 1, highlighting the places where $r \neq 0$ makes a difference. Start from

$$a(r)\, Z = \text{nfa} + B$$

and use the fact that the budget constraint implies $C = rA + Z$, so $Z = C - rA$. Hence, we get

$$a(r)\,(C - r(\text{nfa} + B)) = \text{nfa} + B$$

so

$$A = \frac{a(r)}{1 + ra(r)} C = \text{nfa} + B$$

The long-run government budget constraint (14) is now

$$\frac{P_H}{P}(T - G) = rB$$

The steady state budget constraint (37) now implies

$$\begin{aligned} C &= rA + Z \\ &= rA + \frac{P_H}{P}(Y - T) \\ &= r\text{nfa} + p_H(Q)(Y - G) \end{aligned} \tag{79}$$

where we have substituted in the government budget constraint, asset market clearing $A = B + \text{nfa}$, and the relation $p_H(Q)$ between the relative price P_H/P and the real exchange rate Q. Multiplying the goods market clearing condition (59) by $\frac{P_H}{P}$, and combining, we now have:

$$C = \frac{r\text{nfa} + \alpha p_H(Q)\left(p_H^*(Q)\right)^{-\gamma} C^*}{1 - (1 - \alpha)\left(p_H(Q)\right)^{1-\eta}} \tag{80}$$

which replaces equation (61). We can also write (79) as

$$Y = G + (C - r\text{nfa}) / p_H(Q) \tag{81}$$

which replaces equation (62). Finally (9) at $\pi_w = 0$, replacing $Z = \frac{C}{1+ra(r)}$,

$$\frac{Y}{\Theta} v'\left(\frac{Y}{Y}\right) = \frac{\epsilon_w}{\epsilon_w - 1}(1 - \lambda)\frac{C}{1 + ra(r)} u'(C) \tag{82}$$

which replaces (63). Differentiating starting from nfa $= 0$, we get

$$\begin{aligned}
\widehat{C} &= \frac{r}{\alpha} d\text{nfa} + \frac{\chi - 1}{1 - \alpha} \widehat{Q} \\
\widehat{Y} &= \frac{G}{Y} \widehat{G} + \left(1 - \frac{G}{Y}\right) \left(\widehat{C} - r d\text{nfa} + \frac{\alpha}{1 - \alpha} \widehat{Q}\right) \\
\widehat{Y} &= \frac{1 - \sigma}{1 + \phi} \widehat{C} \\
dB + d\text{nfa} &= A \cdot \widehat{C}
\end{aligned}$$

which gives us a system of 4 equations in 4 unknowns $\left(\widehat{C}, \widehat{Q}, \widehat{Y}, d\text{nfa}\right)$ as a function of dB, dG. The solution is given by

$$d\text{nfa} \left(\frac{rA\left(1 - \frac{G}{Y}\right)\left(1 + \frac{1}{\chi - 1}\right)}{\frac{\sigma - 1}{1 + \phi} + \left(1 - \frac{G}{Y}\right)\left(1 + \frac{\alpha}{\chi - 1}\right)} - 1 \right) = dB + \frac{A}{\frac{\sigma - 1}{1 + \phi} + \left(1 - \frac{G}{Y}\right)\left(1 + \frac{\alpha}{\chi - 1}\right)} \frac{dG}{Y}$$

which gives, in the case of $dG = 0$,

$$LRPT = \frac{d\text{nfa}}{dB} = \frac{1}{1 - \frac{rA\left(1 - \frac{G}{Y}\right)\left(1 + \frac{1}{\chi - 1}\right)}{\frac{\sigma - 1}{1 + \phi} + \left(1 - \frac{G}{Y}\right)\left(1 + \frac{\alpha}{\chi - 1}\right)}}$$

which is, in general, greater than 1.

Dynamics. Section B.2 covered the proof in the general case with $r \neq 0$. To summarize, Proposition 3 holds provided that we replace the fiscal deficit d**FD** by the primary deficit d**PD** and the current account deficit $-d$**CA** by the trade deficit d**TD**.

B.5 Lump-sum transfers

So far we have studied debt-financed transfer increases that occur through the regular tax schedule, and that therefore benefit the rich more in absolute terms. This allows for simple analytics, but many transfer programs (such as stimulus checks) are distributed more progressively. We now study this type of case, extending proposition 3. The dynamics of output, private saving and the current account after these alternative distributions of transfers are determined by:

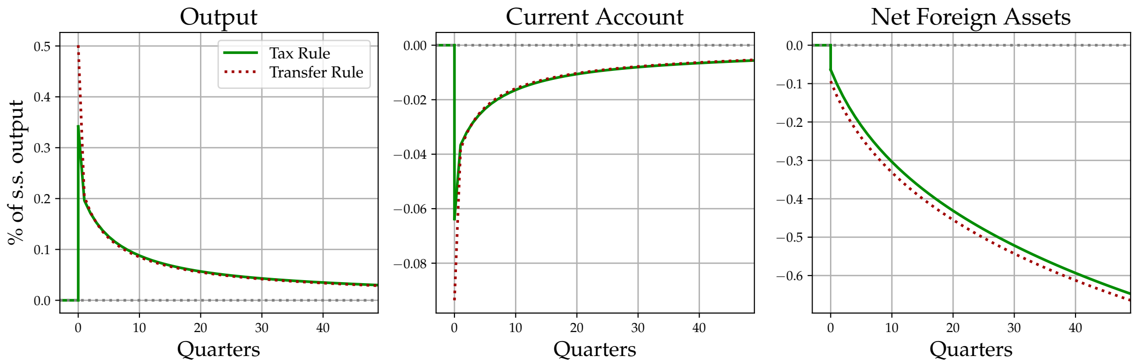


Figure 17: Impulse response to a transfer under alternative transfer distribution rules

$$d\mathbf{Y} = (1-\alpha)\left(\sum_{k\geq 0}(1-\alpha)^k \mathbf{M}^k\right)\widetilde{\mathbf{M}}d\mathbf{FD} \tag{83}$$

$$d\mathbf{CA} = -\alpha\left(\sum_{k\geq 0}(1-\alpha)^k \mathbf{M}^k\right)\widetilde{\mathbf{M}}d\mathbf{FD} \tag{84}$$

$$d\mathbf{PS} = \left(\sum_{k\geq 0}(1-\alpha)^k \mathbf{M}^k\right)\left(I-\widetilde{\mathbf{M}}\right)d\mathbf{FD} \tag{85}$$

where $\widetilde{M}_{t,s} = \frac{\partial C_t}{\partial Tr_s}$ is now the consumption response to transfers Tr_s, which can have a different incidence than after-tax income. For instance, in the case of lump-sum transfers, $\widetilde{\mathbf{M}}$ corresponds to an equal-weighted rather than income-weighted average MPC. These equations show that the MPCs that matter for the effect of the policy, $\widetilde{\mathbf{M}}\boldsymbol{e}_0$, are different from those that matter in aggregate for the dynamic propagation of shocks, which are still given by $\mathbf{M}$.

Figure 17 shows that, compared to proportional transfers, lump-sum transfers have a larger output effect since they benefit higher MPC households on average. However, the current account and savings dynamics are very similar. In other words, while the exact distribution of transfers is critical to understanding which agent is affected, and how much of an immediate effect on output we obtain (with better-targeted transfers boosting output by more), the aggregate dynamics of domestic and foreign wealth accumulation conditional on a given path of government debt are governed by the same general forces, irrespective of how the transfers are distributed.

B.6 TANK model

In the TANK model, a fraction $1-\mu$ behaves like infinitely-lived unconstrained agents (u) and fraction μ behaves like hand-to-mouth constrained agents. The Euler equation and budget constraint for the unconstrained households are, respectively:

$$\begin{aligned} C_{u,t}^{-\sigma} &= \beta\left(1+r_{t+1}^{p}\right)C_{u,t+1}^{-\sigma} \\ A_{u,t} &= \left(1+r_{t}^{p}\right)A_{u,t-1}+Z_t-C_{u,t} \end{aligned}$$

while constrained household just consume their income,

$$C_{c,t}=Z_t$$

Aggregation implies

$$\begin{aligned} C_t &= \mu Z_t+(1-\mu)\,C_{u,t} \\ A_t &= \mu\times 0+(1-\mu)\,A_{u,t} \end{aligned}$$

In steady state, $C_t=C$, $Z_t=Z$ and $C_{u,t}=C_u$, implying giving $\beta\left(1+r^{p}\right)=1$. With $r=0$, we have:

$$\begin{aligned} C_{u,t} &= \overline{C_u}=C_u^{ss} \\ A_{u,t} &= A_{u,t-1}+Z_t-C_u^{ss} \end{aligned} \tag{86}$$

Since $Z_t=Y_t-T_t$ where $T_t=B_{t-1}-B_t+G_t$. As a result, we have

$$\begin{aligned} C_t &= \mu Z_t+(1-\mu)\,C_u^{ss} \\ &= \mu\left(Y_t-T_t\right)+(1-\mu)\,C_u^{ss} \end{aligned} \tag{87}$$

At constant r, we have $Q=1$. Goods market clearing

$$\omega C^{*}+(1-\alpha)\,C_t=Y_t-G_t$$

combined with (87) implies

$$\frac{1}{1-\alpha}\left(Y_t-G_t-C^{*}C^{*}\right) = \mu\left(Y_t-T_t\right)+(1-\mu)\,C_u^{ss}$$

solving out, , we obtain

$$Y_t = \frac{1-\alpha}{1-\mu(1-\alpha)} \left((1-\mu) C_u^{ss} + \frac{\omega}{1-\alpha} C^* + \frac{1}{1-\alpha} G_t - \mu T_t \right)$$

We can write this in terms of the fiscal deficit $FD_t = G_t - T_t$ as $T_t = G_t - FD_t$, as

$$Y_t = \frac{(1-\alpha)(1-\mu) C_u^{ss} + \omega C^*}{1-\mu(1-\alpha)} + G_t + \frac{\mu(1-\alpha)}{1-\mu(1-\alpha)} FD_t$$

which implies in particular

$$d\boldsymbol{Y} = d\boldsymbol{G} + \frac{\mu(1-\alpha)}{1-\mu(1-\alpha)} d\boldsymbol{FD} \tag{88}$$

as claimed in the text. Moreover, we have:

$$\begin{aligned} Z_t &= Y_t - T_t \\ &= \frac{(1-\alpha)(1-\mu) C_u^{ss} + \omega C^*}{1-\mu(1-\alpha)} + \left(1 + \frac{\mu(1-\alpha)}{1-\mu(1-\alpha)}\right) FD_t \\ &= \frac{(1-\alpha)(1-\mu) C_u^{ss} + \omega C^*}{1-\mu(1-\alpha)} + \frac{1}{1-\mu(1-\alpha)} FD_t \end{aligned}$$

Substitute in asset dynamics (86) to get

$$\begin{aligned} A_t - A_{t-1} &= (1-\mu)(A_{u,t} - A_{u,t-1}) \\ &= (1-\mu)(Z_t - C_u^{ss}) \\ &= \frac{1-\mu}{1-\mu(1-\alpha)} FD_t \end{aligned}$$

This implies that the current account is

$$CA_t = \text{nfa}_t - \text{nfa}_{t-1} = A_t - A_{t-1} - FD_t = \left(\frac{1-\mu}{1-\mu+\alpha\mu} - 1\right) = \frac{-\mu\alpha}{1-\mu(1-\alpha)} FD_t$$

implying in particular:

$$-d\boldsymbol{CA} = \frac{\mu\alpha}{1-\mu(1-\alpha)} d\boldsymbol{FD} \tag{89}$$

Equations (88) and (89) show that, for TANK, proposition 3 applies with $\boldsymbol{M} = \mu \boldsymbol{I}$.

To see what this implies for the steady state, integrate the asset equation. This shows:

$$\Delta A = \frac{1-\mu}{1-\mu\left(1-\alpha\right)}\Delta B \tag{90}$$

$$\Delta \text{nfa} = \frac{-\mu\alpha}{1-\mu\left(1-\alpha\right)}\Delta B \tag{91}$$

where the Δ applies between any time t and the initial steady state, and in particular between the initial and the final steady state.

In particular, we have:

$$LPRT = -\frac{\Delta \text{nfa}}{\Delta B} = \frac{\mu\alpha}{1-\mu\left(1-\alpha\right)}$$

To draw figure 7, we calibrate μ to a certain $mpc_0 = 0.25$ and $\alpha = 0.16$, as in our main model. The TANK model does not have another degree of freedom for MPCs.

B.7 Blanchard model

Here we consider a discrete-time version of the Blanchard (1985) model. This is one of the simplest models of non-Ricardian agents that can be consistent with the data on iMPCs.

The model is as follows. Agents have infinite planning horizons, discount the future at rate β, and have a constant probability of death each period. Specifically, their probability of surviving to period t is $\Phi_t = \phi^t$, where ϕ is the (constant) period survival probability which here is taken to be a constant. This setting implies that agents' expected lifetime is $\frac{1}{1-\phi}$. Moreover, in a stationary distribution, the size of a cohort of age j is proportional to ϕ^j. Since $\sum \phi^a = \frac{1}{1-\phi}$, the share of agents of age j is $\pi_j = (1-\phi)\,\phi^j$.

The model is set up such that there is no within-cohort heterogeneity: all agents aged j at time t (so from the same cohort $k = t-j$) receive the same income $z_{j,t}$. However, there is a lot of heterogeneity across-cohort.

Specifically, the problem of an agent born in cohort k, going through ages $j = t-k$ (where t denotes calendar time) is:

$$\begin{aligned} \max \quad & E_k\left[\sum_j \beta^j \phi^j \log\left(c_{jt}\right)\right] \\ s.t. \quad & c_{j,t} + a_{j+1,t+1} = \frac{(1+r_t)}{\phi} a_{j,t} + z_{j,t} \end{aligned} \tag{92}$$

where $z_{j,t}$ is post-tax income of an agent aged j at time t. Here, agents have access to annuities $a_{j,t}$ that pay a return $\frac{(1+r_t)}{\phi}$ conditional on not dying, such that the assets of the dying are distributed equally among the remaining members of the cohort.

We consider the extension of the canonical Blanchard model in which age profiles decay with age at rate ζ:

$$z_{j,t} \propto (1-\zeta)^j Z_t \tag{93}$$

where Z_t denotes aggregate income. This front-loaded income profile generates a life-cycle motive to save, which is essential to deliver positive asset accumulation in the steady state at $r = 0$ (the canonical Blanchard model then corresponds to $\zeta = 0$).

Given log utility and the presence of annuities, individual consumption follows

$$c_{j,t} = (1-\phi\beta)\frac{(1+r_t)}{\phi}\left(a_{j,t} + h_{j,t}\right) \tag{94}$$

where human capital is given by:

$$h_{j,t} = \frac{\phi}{1+r_t}\left(z_{j,t} + (1-\zeta)\, h_{j+1,t+1}\right) \tag{95}$$

This leads us the the following proposition.

Proposition 5. *Aggregate dynamics in the Blanchard model are given by the asset demand function $A_t = A_t(\{r_s, Z_s\})$ and the consumption function $C_t = C_t(\{r_s, Z_s\})$ that solve the system of three equations:*

$$\begin{aligned} H_t &= \frac{\phi}{1+r_t}\left(Z_t + (1-\zeta)\, H_{t+1}\right) & (96)\\ C_t &= (1-\phi\beta)\frac{(1+r_t)}{\phi}\left(A_{t-1} + H_t\right) & (97)\\ C_t + A_t &= (1+r_t)\, A_{t-1} + Z_t & (98)\end{aligned}$$

Moreover, the long-run asset demand curve is given by:

$$A = a(r)\, Z \qquad \textit{where} \qquad a(r) = \frac{1-(1-\phi\beta)\frac{1+r}{1+r-\phi(1-\zeta)}}{(1-\phi\beta)\frac{(1+r)}{\phi} - r}$$

Proposition (5), which follows from aggregation of equations (95), (94) and (92), respectively, using the stationary distribution $\pi_j = (1-\phi)\,\phi^j$, is the discrete-time counterpart of equations (19)–(21) in Blanchard (1985).

We can further characterize analytically the steady state dynamics implied by equation (5), i.e. the Jacobians of the A and C functions. We focus on the first column of $M =$

$\frac{\partial C_t}{\partial Z_s}$, since this gives us the dynamic MPCs from unexpected income shocks that we can calibrate the model to. It is possible to show:

Proposition 6. *In the Blanchard model, the first column of the M matrix is given by*

$$M_{t,0} = \frac{\partial C_t}{\partial Z_0} = \begin{cases} (1-\beta\phi) & t = 0 \\ (1-\beta\phi)\,\beta\left(1+\beta-\frac{1}{\phi}\right)^t & t > 0 \end{cases}$$

Note that ζ does not appear in these equations—instead, ζ controls the degree of anticipation of future income shocks.

Given Proposition 6, we calibrate the household side of the Blanchard model by picking (β,ϕ) jointly to hit $mpc = M_{0,0} = 0.25$ and a certain target for $M_{1,0}$. Given the constraint that $\phi < 1$, Proposition 6 implies that we must pick $mpc\,(1-mpc) < M_{1,0}$. We choose $M_{1,0} = 0.2$. We then pick $\alpha = 0.16$ as in our main calibration. This delivers figure 7.

B.8 Bond-in-utility model

Here, we set up a bond-in-the utility model. We then show that, for its response to income, this model is first-order equivalent to the Blanchard model.

The agent maximizes the objective

$$\sum \beta^t \left\{u\left(C_t\right) + v\left(A_t\right)\right\}$$

where v is a love-of-asset function, subject to the same aggregate budget constraint as in our main HANK model, (37). The Euler equation for this problem is:

$$u'\left(C_t\right) = \beta\left(1+r_{t+1}\right)u'\left(C_{t+1}\right) + v'\left(A_t\right) \tag{99}$$

and the steady state is characterized by:

$$u'\left(rA+Z\right)\left(1-\beta\left(1+r\right)\right) = v'\left(A\right)$$

Assuming homothetic utility $u'\left(c\right) = c^{-\sigma}$, $v'\left(a\right) = a^{-\sigma}$, this can be rewritten as:

$$\left(r+\frac{Z}{A}\right) = \left(1-\beta\left(1+r\right)\right)^{\frac{1}{\sigma}}$$

Hence, the steady-state asset demand function is

$$A = a(r) Z$$

where, here:

$$a(r) = \frac{A}{Z} = \frac{1}{(1-\beta(1+r))^{\frac{1}{\sigma}} - r}$$

The dynamics at a constant real rate r can be characterized by differentiating (99) and (37). This delivers:

$$\begin{aligned} u''(C) dC_t &= \beta(1+r) u''(C) dC_{t+1} + v''(A) dA_{t+1} \\ dC_t + dA_{t+1} &= (1+r) dA_t + dZ_t \end{aligned}$$

Combining, we obtain:

$$\beta(1+r) dA_{t+1} - \left(1 + \frac{v''(A)}{u''(C)} + \beta(1+r)^2\right) dA_t + (1+r) dA_{t-1} = -dZ_t + \beta(1+r) dZ_{t+1}$$

which we rearrange as:

$$dA_{t+1} - \frac{1}{\beta(1+r)}\left(1 + \frac{v''(A)}{u''(C)} + \beta(1+r)^2\right) dA_t + \frac{1}{\beta} dA_{t-1} = -\frac{1}{\beta(1+r)} dZ_t + dZ_{t+1} \tag{100}$$

Let λ and $\frac{1}{\beta\lambda}$ be the roots of

$$C(X) = X^2 - \frac{1}{\beta(1+r)}\left(1 + \frac{v''(A)}{u''(C)} + \beta(1+r)^2\right) X + \frac{1}{\beta}$$

Then (100) rewrites as

$$dA_{t+1} - \left(\lambda + \frac{1}{\beta\lambda}\right) dA_t + \frac{1}{\beta} dA_{t-1} = -\frac{1}{\beta(1+r)} dZ_t + dZ_{t+1}$$

This leads us to the following.

Proposition 7. *Assume that the bond-in-the-utility model is parameterized such that*

$$\begin{aligned}
\beta^{BU} &= \frac{1}{\left(\frac{1+r}{\phi}\right)^2 \frac{1}{1-\zeta}\left(\phi\left(1+\beta\right)-1\right)} \\
\frac{1}{\beta^{BU}\left(1+r^{BU}\right)} &= \frac{\beta\phi}{\kappa}
\end{aligned}$$

and that $\frac{v''(A)}{u''(C)}$ *is picked so that* $\lambda^{BU} = \frac{1}{\kappa}$*. Then, the BU model and the Blanchard model share the same* $\mathbf{M}$ *matrix, that is, to first order they have identical responses to income shocks at any date.*

B.9 Covid shock to home spending

As mentioned in the text, to model the Covid shock to home spending, we modify the household problem so that consumption is defined as:

$$c_{it}^{k} = \left[\left(\left(1-\alpha^{k}\right)\right)^{\frac{1}{\eta}}\left(\zeta_t c_{iHt}^{k}\right)^{\frac{\eta-1}{\eta}} + \left(\alpha^{k}\right)^{\frac{1}{\eta}}\left(c_{iWt}^{k}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

Given this new definition, equation (3) is modified to be

$$\begin{aligned}
V_t\left(A,e\right) \quad &= \quad \max_{c_F, c_H, a'} u\left(c_t\left(c_H, c_W\right)\right) - v\left(N_t\right) + \beta\mathbb{E}_t\left[V_{t+1}\left(A', e'\right)\right] \\
\text{s.t.} \quad & P_{Ht}c_H + \sum_{l=1}^{K} P_{lt}c_W^{l} + A' = \left(1+r_t^{p}\right)\frac{P_t}{P_{t-1}}A + P_t \cdot \nu_t\left(e\frac{W_t}{P_t}N_t\right)^{1-\lambda} \\
& A' \geq 0
\end{aligned} \tag{101}$$

This gives rise to a new demand system:

$$c_H = (1-\alpha)\left(\frac{P_H}{\zeta P^{mod}}\right)^{-\eta}\frac{c}{\zeta} \qquad c_F = \alpha\left(\frac{P_{Ft}}{P^{mod}}\right)^{-\eta} c \tag{102}$$

where P^{mod}, the modified price index, is given by

$$P^{mod} = \left[(1-\alpha)\left(\frac{P_H}{\zeta}\right)^{1-\eta} + \alpha\left(P_W\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{103}$$

with the Cobb Douglas limit $\eta = 1$ being $P^{mod} = \left(\frac{P_H}{\zeta}\right)^{1-\alpha}\left(P_W\right)^{\alpha}$.

We can modify the household problem as follows. The household perceives real post-tax income to be equal to

$$\frac{e^{1-\lambda}}{\mathbb{E}\left[e^{1-\lambda}\right]}\frac{Z_t}{P_t^{mod}/P_t}$$

which effectively implies that it perceives real income to be $Z_t^{mod}=\frac{Z_t}{P_t^{mod}/P_t}$. Similarly, it perceives the ex-post real interest rate to be:

$$1+r_t^{mod,post}=\left(1+r_t^{post}\right)\cdot\frac{P_{t-1}^{mod}/P_{t-1}}{P_t^{mod}/P_t}$$

Given the paths $\left\{r_t^{mod},P_t^{mod}\right\}$, households solve their problem to determine consumption c^{mod}, then allocates demand per (102), ie:

$$c_H=(1-\alpha)\left(\frac{P_H}{\zeta P^{mod}}\right)^{-\eta}\frac{c^{mod}}{\zeta}\qquad c_F=\alpha\left(\frac{P_{Ft}}{P^{mod}}\right)^{-\eta}c^{mod}$$

We obtain $\frac{P^{mod}}{P}$ from:

$$\frac{P^{mod}}{P}=\left(\frac{(1-\alpha)\left(\frac{P_H}{\zeta}\right)^{1-\eta}+\alpha\left(P_W\right)^{1-\eta}}{(1-\alpha)\left(P_H\right)^{1-\eta}+\alpha\left(P_W\right)^{1-\eta}}\right)^{\frac{1}{1-\eta}}=\left(\frac{(1-\alpha)\left(\frac{1}{\zeta}\right)^{1-\eta}+\alpha\left(\frac{P_W}{P_H}\right)^{1-\eta}}{(1-\alpha)\left(1\right)^{1-\eta}+\alpha\left(\frac{P_W}{P_H}\right)^{1-\eta}}\right)^{\frac{1}{1-\eta}}$$

as well as the relevant relative prices from:

$$\frac{P_H}{P^{mod}}=\frac{P_H}{P}\cdot\frac{1}{P^{mod}/P}\qquad\frac{P_F}{P^{mod}}=\frac{P_F}{P}\cdot\frac{1}{P^{mod}/P}$$

Finally we can recreate aggregate c using:

$$\frac{P_H}{P}c_H+\frac{P_F}{P}c_F$$

C Appendix to section 4

C.1 Proof of Proposition 4

We start by proving the following two more abstract lemmas.

Lemma 2. *Suppose that we have a number of countries k, for all of which some vectors $\mathbf{X}^k$ and $\mathbf{Y}^k$ obey some equation*

$$F(\mathbf{X}^k,\mathbf{Y}^k)=0\tag{104}$$

which is either homogeneous of degree 1 or homogeneous of degree 0 in $\mathbf{X}^k$. Furthermore, suppose that in steady state, each country satisfies $\mathbf{X}^{k,ss} = \omega^k \mathbf{X}^{ss}$ for scalars ω^k summing to 1 and some $\mathbf{X}^{ss}$; and it also satisfies $\mathbf{Y}^{k,ss} = \mathbf{Y}^{ss}$ for some common $\mathbf{Y}^{ss}$.

Away from the steady state, for any $\mathbf{X}^k$ and $\mathbf{Y}^k$ all satisfying (104) above, define $\mathbf{X} \equiv \sum_k \mathbf{X}^k$ and $\mathbf{Y} \equiv \sum_k \omega^k \mathbf{Y}^k$. Then to first order around the steady state $(\mathbf{X}^{ss}, \mathbf{Y}^{ss})$, $F(\mathbf{X}, \mathbf{Y}) = 0$.

Proof. First, note that our assumptions imply $F(\mathbf{X}^{ss}, \mathbf{Y}^{ss}) = 0$ regardless of whether F is homogeneous of degree 1 or 0.

Next, totally differentiate (104) for each k to obtain

$$dF(\mathbf{X}^k, \mathbf{Y}^k) = \frac{\partial F}{\partial \mathbf{X}^k} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}^k} d\mathbf{Y}^k = 0 \tag{105}$$

where $\frac{\partial F}{\partial \mathbf{X}^k}$ and $\frac{\partial F}{\partial \mathbf{Y}^k}$ denote derivatives taken around the country-k steady state $(\mathbf{X}^{k,ss}, \mathbf{Y}^{k,ss})$. Then we have two cases:

- If F is homogeneous of degree 1 in $\mathbf{X}^k$, then $\frac{\partial F}{\partial \mathbf{X}^k} = \frac{\partial F}{\partial \mathbf{X}}$ and $\frac{\partial F}{\partial \mathbf{Y}^k} = \omega^k \frac{\partial F}{\partial \mathbf{Y}}$, where $\frac{\partial F}{\partial \mathbf{X}}$ and $\frac{\partial F}{\partial \mathbf{Y}}$ are taken around $(\mathbf{X}^{ss}, \mathbf{Y}^{ss})$. Summing (105) across all k we get

$$\sum_k \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}} \omega^k d\mathbf{Y}^k = \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X} + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y}$$

- If F is homogeneous of degree 0 in $\mathbf{X}^k$, then $\frac{\partial F}{\partial \mathbf{X}^k} = \frac{1}{\omega^k} \frac{\partial F}{\partial \mathbf{X}}$ and $\frac{\partial F}{\partial \mathbf{Y}^k} = \frac{\partial F}{\partial \mathbf{Y}}$. Summing (105) across all k, weighted by ω^k, we get

$$\sum_k \omega^k \left(\frac{1}{\omega^k} \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y}^k \right) = \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X} + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y}$$

Hence, in both cases we obtain $\frac{\partial F}{\partial \mathbf{X}} d\mathbf{X} + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y} = 0$ for the aggregate economy, validating our claim that $F(\mathbf{X}, \mathbf{Y}) = 0$ holds to first order.

□

Lemma 3. *Under the same assumptions as in lemma 2, define $\tilde{\mathbf{X}}^k = \frac{\mathbf{X}^k}{\omega^k} - \mathbf{X}$ and $\tilde{\mathbf{Y}}^k = \mathbf{Y}^k - \mathbf{Y}$. Then to first order around the steady state $(\mathbf{X}^{ss}, \mathbf{Y}^{ss})$, $F(\mathbf{X}^{ss} + \tilde{\mathbf{X}}^k, \mathbf{Y}^{ss} + \tilde{\mathbf{Y}}^k) = 0$.*

Proof. Now taking all derivatives around the aggregate steady state $(\mathbf{X}^{ss}, \mathbf{Y}^{ss})$, we want to show $\frac{\partial F}{\partial \mathbf{X}} d\tilde{\mathbf{X}}^k + \frac{\partial F}{\partial \mathbf{Y}} d\tilde{\mathbf{Y}}^k = 0$. We can write

$$\frac{\partial F}{\partial \mathbf{X}} d\tilde{\mathbf{X}}^k + \frac{\partial F}{\partial \mathbf{Y}} d\tilde{\mathbf{Y}}^k = \frac{1}{\omega^k} \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y}^k - \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X} - \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y} \tag{106}$$

We note that $\frac{\partial F}{\partial \mathbf{X}} d\mathbf{X} + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y} = 0$ is what we've already proven in lemma 2, while $\frac{1}{\omega^k} \frac{\partial F}{\partial \mathbf{X}} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}} d\mathbf{Y}^k$ is proportional to $\frac{\partial F}{\partial \mathbf{X}^k} d\mathbf{X}^k + \frac{\partial F}{\partial \mathbf{Y}^k} d\mathbf{Y}^k = 0$, either by a factor of $\frac{1}{\omega^k}$ (if F homogeneous of degree 1) or a factor of 1 (if F homogeneous of degree 0), and this holds by our assumption (104). Hence the right of (106) is zero, as desired. $\square$

Next, we apply these two lemmas to prove the claims of proposition 4.

We start by observing that any open economy equilibrium in any country k, as defined in definition 3, is fully characterized by equations (7)–(19), (22)–(29), demands (5) and (20), and the sequence-space equations (36) for aggregate assets and consumption, all conditional on some given world $\{i_t^*\}$ and $\{C_t^*\}$. All these equations satisfy the assumption stated in lemma 2, being either homogeneous of degree 1 in the variables that scale with ω^k (e.g. the government budget constraint (14)) or homogeneous of degree 0 (e.g. the relationship (13) between price and wage inflation).

It follows immediately from lemma 2 that if each of these equations holds for each country k, then to first order around the aggregate steady state, they each hold in aggregates as well. Hence, to first order, the path of aggregates satisfies the equations for an open economy.

We further argue that (31) and (33), which together characterize world economy equilibrium, will also hold in aggregates *as if* in a one-country world. This is clearly true in steady state, where given the normalizations $P_H^k, \mathcal{E}^k, Q^k \equiv 1$, (31) immediately holds and (33) is just $\text{nfa} = 0$ for the aggregate $\text{nfa} \equiv \sum \text{nfa}^k$. This is also true to first order away from the steady state, where linearizing (31) gives $\sum_k \omega^k (dP_{Ht}^k - d\mathcal{E}_t^k) = 0$, reducing to just $dP_{Ht} - d\mathcal{E}_t = 0$ in aggregates, and linearizing (33) gives $\sum_k d\text{nfa}_t^k = 0$, reducing to just $d\text{nfa}_t = 0$ in aggregates.

We conclude that to first order around the steady state, aggregate variables obey all the equations of the world equilibrium model with a single country. This proves the first part of proposition 4.

For the second part, it follows immediately from lemma 3 that the demeaned variables satisfy, to first order around the world steady state, all the equations of an open economy. We further note that the global variables i_t^* and C_t^* have demeaned values always equal to zero, since their value in each country equals their mean: $\tilde{i}_t^* = \tilde{C}_t^* = 0$. Hence the demeaned response is equivalent to a small open economy response where i_t^* and C_t^* are held constant, as desired.

C.2 Proof of Corollary 1

All that remains is to derive the formula (51) for the change dr^n in steady-state real interest rate. Letting $a(r)$ denote steady-state asset demand normalized by after-tax income, asset market clearing is

$$Za(r) = B$$

In the steady state, post-tax income is

$$Z = Y - G - rB$$

and the natural allocation with zero wage inflation, ((9)) implies that the condition

$$v'(N)N = v'\left(\frac{Y}{\Theta}\right)\frac{Y}{\Theta} = \frac{\epsilon_w}{\epsilon_w - 1}(1-\lambda)Zu'(C)$$

must hold for each individual country, with steady-state $C = Z + rB = (1 + ra(r))Z$.

Using our functional forms for v and u and combining these equations, we obtain:

$$\varphi\left(\frac{Y}{\Theta}\right)^{1+\phi} = \frac{\epsilon_w}{\epsilon_w - 1}(1-\lambda)\left(\frac{B}{a(r)}\right)^{1-\sigma}(1+ra(r))^{-\sigma} \tag{107}$$

$$(Y-G)a(r) = (1+ra(r))B \tag{108}$$

Log-differencing and assuming $d\log G = 0$, we find

$$\begin{aligned}(1+\phi)d\log Y &= (1-\sigma)(d\log B - d\log a(r)) - \sigma d\log(1+ra(r)) \\ \frac{1}{1-\frac{G}{Y}}d\log Y &= d\log(1+ra(r)) + (d\log B - d\log a(r))\end{aligned}$$

which gives

$$d\log B - d\log a(r) = -\frac{1 + \frac{1}{1-\frac{G}{Y}}\frac{\sigma}{1+\phi}}{1 - \frac{1}{1-\frac{G}{Y}}\frac{1-\sigma}{1+\phi}}d\log(1+ra(r))$$

Noting finally that, around $r = 0$, we have $d\log(1+ra(r)) = \frac{a(r)+ra'(r)}{1+ra(r)}dr = a(r)dr$, we obtain

$$dr = \frac{d\log B}{\frac{d\log a(r)}{dr} - \frac{1+\frac{1}{1-\frac{G}{Y}}\frac{\sigma}{1+\phi}}{1-\frac{1}{1-\frac{G}{Y}}\frac{1-\sigma}{1+\phi}}a(r)}$$

which is the formula in the main text.

D Appendix to section 5

D.1 Data sources and country list

Table 4 lists the 26 economies in our study, which are the advanced economies that have non-missing data on fiscal deficits (general government net lending and borrowing) and current accounts between 2020Q1 and 2021Q2. The table also indicates, under column "R?", if countries are part of our "reduced sample" that also includes private savings and investment data over this period.

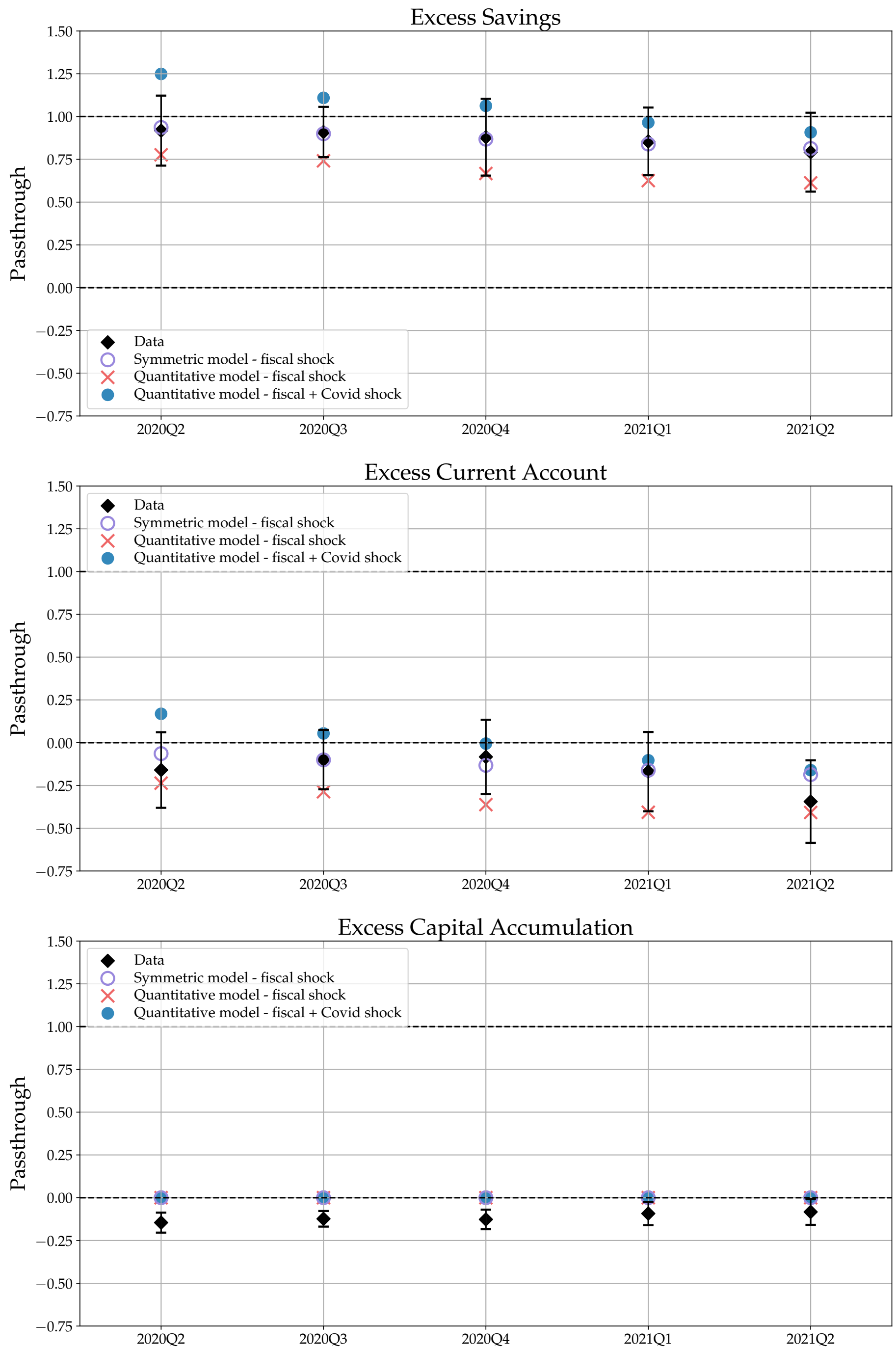
The data used in section D is collected as follows. General Government net lending and borrowing are from the IMF International Financial Statistics (IFS). Current account data is from the IMF Balance of Payments and International Investment Position Statistics.[37] Private savings are from the OECD Quarterly Non-Financial Sector Accounts, and are computed as gross savings net of consumption of fixed capital for the private sector.[38] Net investment data is from the OECD Quarterly National Accounts, computed as gross fixed capital formation net of the consumption of fixed capital. For the U.S., all data is taken from National Income and Product Accounts. We use seasonally adjusted data when available, otherwise use non-seasonally adjusted data. To construct figure 1 we also construct the trade balance by subtracting imports from exports in the IMF IFS.

The data used to construct the remaining columns of table 4 is constructed as follows. Nominal GDP is from the IMF IFS database; we report nominal GDP weights based on 2020Q1 values as share of total nominal GDP for our 26 countries.

Openness averages the import-to-GDP and export-to-GDP ratio from the World Development Indicators (WDI) over 2015–2019; government spending to GDP is the WDI average over the same period. We use the net debt-to-GDP from the IMF Fiscal Monitor averaged over 2015-2019; for Greece this number is missing and we calculate it by taking general government gross debt from the World Bank Quarterly Public Sector Debt database, and subtracting financial assets from the IFS.

Country	R?	Code	GDP weight Y^k	Openness $\frac{X^k+I^k}{2Y^k}$	Spending G^k/Y^k	Debt B^k/Y^k
United States	Y	US	52.36	13.5	14.1	81.9
Germany	Y	DE	9.32	43.4	19.9	46.3
United Kingdom	Y	GB	7.00	30.1	18.8	76.8
France	Y	FR	6.27	31.4	23.5	88.6
Italy	Y	IT	4.55	29.1	18.9	121.8
Canada	Y	CA	4.12	32.9	20.8	26.4
Australia	Y	AU	3.24	21.4	19.0	24.1
Spain	Y	ES	3.19	32.9	18.9	84.4
Netherlands	Y	NL	2.19	77.7	24.6	46.8
Sweden	Y	SE	1.29	43.2	26.0	7.2
Belgium	N	BE	1.27	80.7	23.2	88.6
Austria	Y	AT	1.05	52.4	19.5	53.9
Denmark	Y	DK	0.85	52.5	24.6	15.0
Finland	Y	FI	0.65	37.5	23.4	22.6
Czech Republic	Y	CZ	0.61	74.6	19.1	22.5
Portugal	Y	PT	0.56	41.7	17.3	115.9
Greece	Y	GR	0.48	36.3	20.3	150.5
Slovakia	N	SK	0.25	92.9	18.9	45.5
Luxembourg	N	LU	0.17	179.4	16.4	-11.2
Lithuania	N	LT	0.13	71.6	16.8	31.9
Slovenia	Y	SI	0.13	77.1	18.6	48.6
Latvia	N	LV	0.08	60.9	18.5	30.1
Estonia	N	EE	0.07	73.9	19.5	-1.9
Cyprus	N	CY	0.06	72.5	15.4	71.5
Iceland	N	IS	0.05	44.5	23.7	62.1
Malta	N	MT	0.04	141.3	16.2	37.5

Table 4: Countries in our sample and their characteristics



Note: These figures provide the dynamic counterpart to figure 12, regressing dA_t^k, $dnfa_t^k$ and dK_t^k on dB_t^k for $t = 1, \cdots, 5$ in our three models and comparing to the empirical counterpart. The empirical regression coefficients are reported with 68% confidence bands.

Figure 18: Dynamic pass-through regressions vs model predictions

D.2 Dynamic regression vs model predictions

D.3 Regression with controls

Figure 19 repeats the exercise from figure 11, but adds controls by residualizing each x-axis variable with the other two variables. For instance, the fiscal deficit is residualized with the lockdown index and Covid deaths, and so on. The patterns from figure 11 are almost identical.[39]

D.4 Accounting for fiscal deficits in the Rest of the World

Figure 20 repeats the exercise from figure 10 for the 16 countries that make up the Rest of the World in our reduced sample, for which all balance of payment data is available.

E Appendix to section 6

E.1 Non-symmetric world economy calibration

Table 5 displays our calibration targets, as well as the outcomes of the model. We take openness α and GDP shares from the data. We then infer the parameter ω so that equation (35) holds. We look for β, δ to simultaneously hit an mpc of 0.25 and an r of 0. Each country has its own wealth distribution; the table reports the top 20% wealth share in each. Given its importance for aggregate dynamics, we also report the second entry of the $\mathbf{M}$ matrix,$M_{1,0}$, across countries.

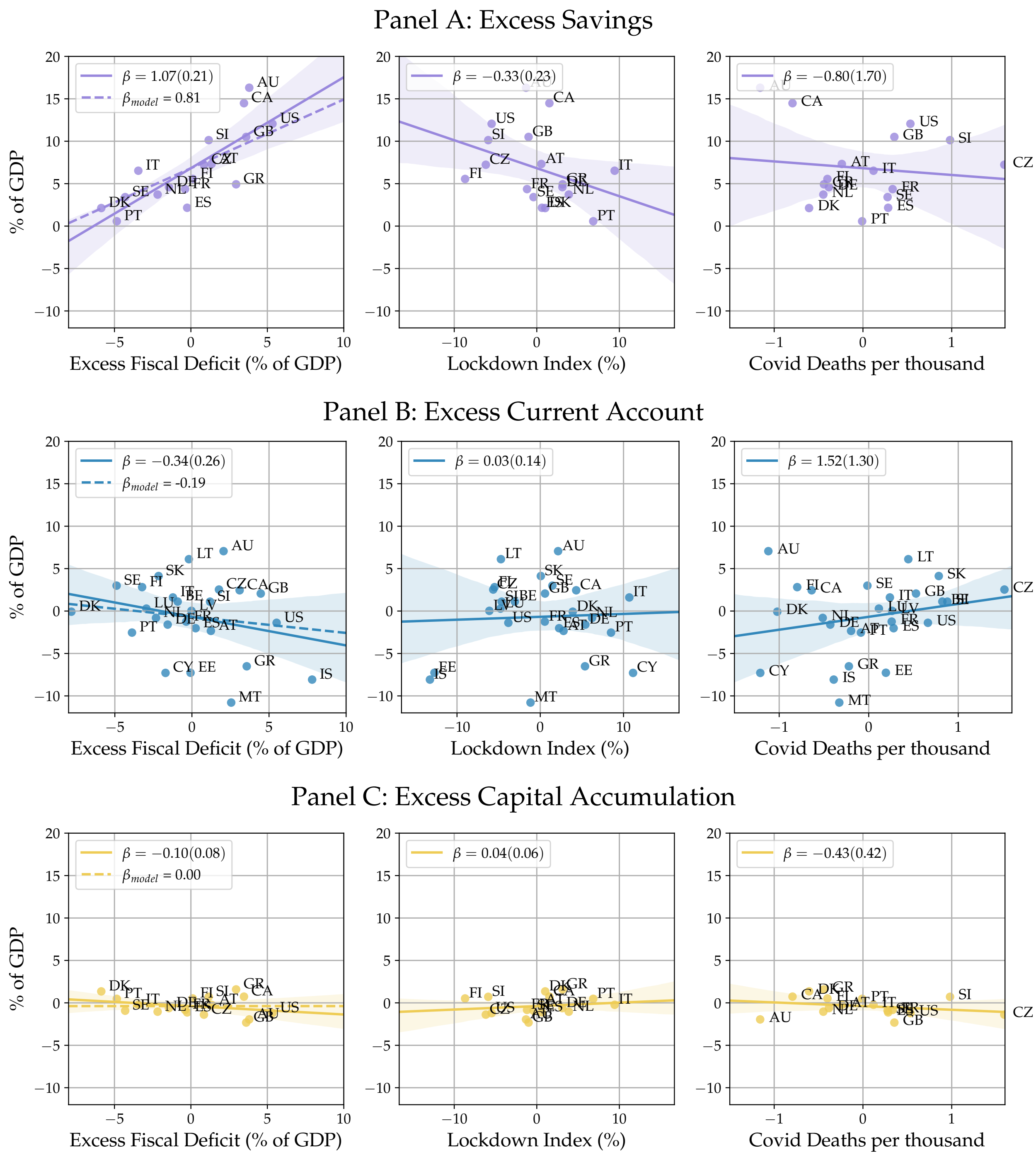
E.2 Solution method for non-symmetric 26-country model

In principle, computation here should be very difficult: we have a 26 country model, with a separate wealth distribution in each country. However, we observe that countries only interact through the two aggregates (C_t^*, i_t^*). This makes it feasible to solve the model to first order very efficiently by adapting the ideas developed in Auclert et al. (2021a).

[37] We take US dollar values for the current account and convert them to domestic currency using period average exchange rates from the IMF IFS.

[38] The private sector consists of households, nonprofits serving households, financial corporations, and non-financial corporations.

[39] The excess savings point estimate is somewhat higher, now 1.07, but this is due to the statistical discrepancy in the national accounts, which is correlated with the residualized fiscal deficit shock. Inferring excess savings from the identity (53) would imply a point estimate of 0.56 rather than 1.07.



Note: β indicates the regression coefficient of the y-axis on the x-axis variable. The latter is the original x axis variable purged of the other two, so that the regression coefficient corresponds to the one in a regression that directly controls for these other variables. The standard error around this coefficient is in parentheses. Shaded areas correspond to 68% bootstrapped confidence intervals.

Figure 19: Determinants of excess savings, investment, and current accounts (with controls)

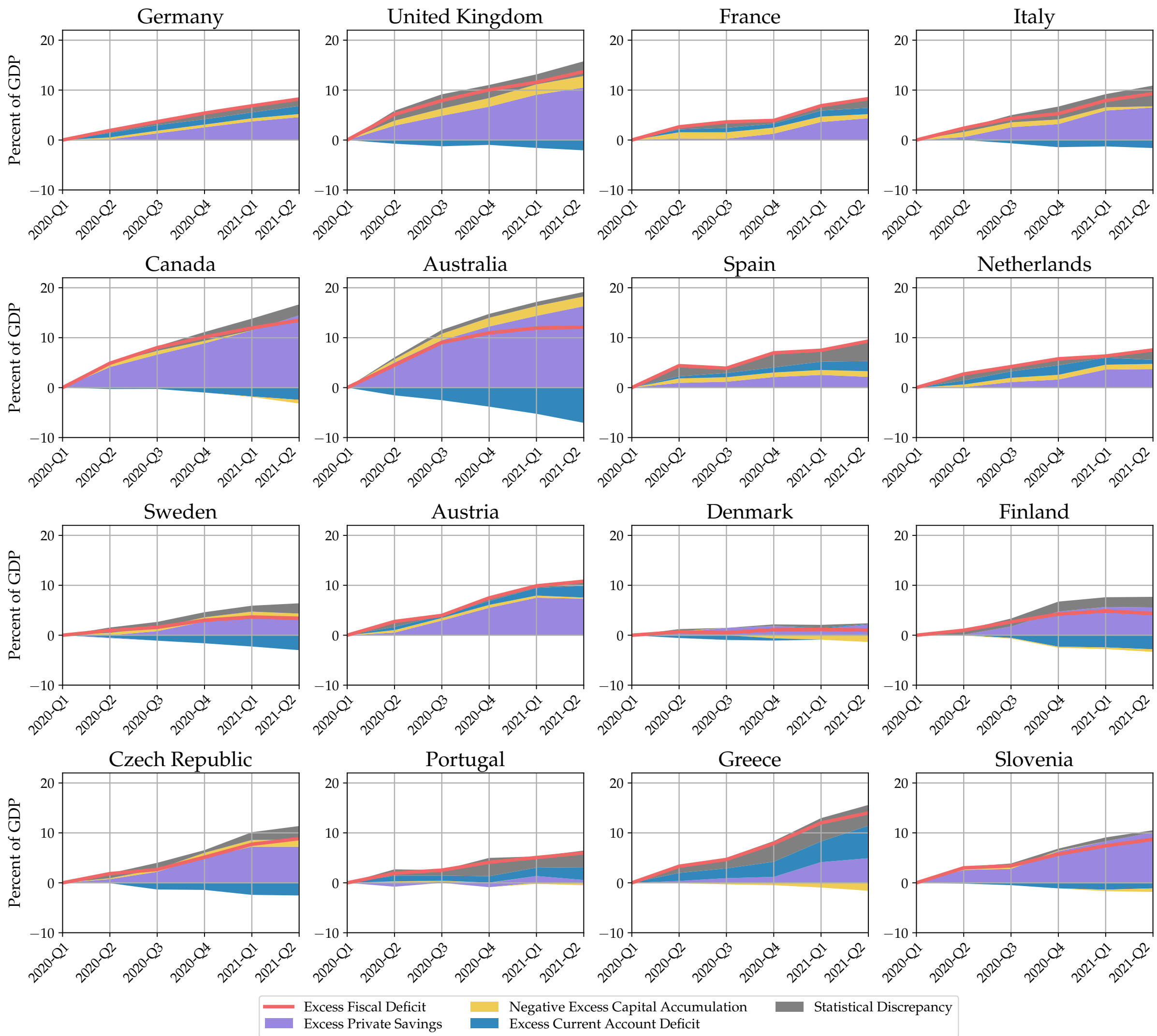


Figure 20: Accounting for fiscal deficits in the Rest of the World

Country	Code	α	ω	mpc	β	δ	$M_{1,0}$	Top 20% wealth share
United States	US	15.7	27.8	0.25	0.99	0.1	0.1	83.9
Germany	DE	54.2	16.2	0.25	0.99	0.1	0.1	84.2
United Kingdom	GB	37	8.6	0.25	0.99	0.1	0.1	84.2
France	FR	41.1	7.9	0.25	0.99	0.1	0.1	84.4
Italy	IT	35.8	5.1	0.25	0.99	0.1	0.1	84.1
Canada	CA	41.5	5.2	0.25	0.99	0.1	0.1	84.3
Australia	AU	26.4	2.7	0.25	0.99	0.1	0.1	84.1
Spain	ES	40.6	4.1	0.25	0.99	0.1	0.1	84.2
Netherlands	NL	90	5.9	0.25	0.99	0.1	0.1	84.5
Sweden	SE	58.3	2.2	0.25	0.99	0.1	0.1	84.5
Belgium	BE	90	3.5	0.25	0.99	0.1	0.1	84.4
Austria	AT	65.1	2.2	0.25	0.99	0.1	0.1	84.3
Denmark	DK	69.6	1.8	0.25	0.99	0.1	0.1	84.5
Finland	FI	49	0.9	0.25	0.99	0.1	0.1	84.4
Czech Republic	CZ	90	1.7	0.25	0.99	0.1	0.1	84.2
Portugal	PT	50.5	0.9	0.25	0.99	0.1	0.1	84.1
Greece	GR	45.6	0.6	0.25	0.99	0.1	0.1	84.3
Slovakia	SK	90	0.7	0.25	0.99	0.1	0.1	84.2
Luxembourg	LU	90	0.5	0.25	0.99	0.1	0.1	84.1
Lithuania	LT	86	0.4	0.25	0.99	0.1	0.1	84.2
Slovenia	SI	90	0.4	0.25	0.99	0.1	0.1	84.2
Latvia	LV	74.7	0.2	0.25	0.99	0.1	0.1	84.2
Estonia	EE	90	0.2	0.25	0.99	0.1	0.1	84.3
Cyprus	CY	85.7	0.2	0.25	0.99	0.1	0.1	84.1
Iceland	IS	58.4	0.1	0.25	0.99	0.1	0.1	84.4
Malta	MT	90	0.1	0.25	0.99	0.1	0.1	84.1

Table 5: Calibration outcomes

Briefly, the idea is to first calculate separately and once and for all, in each country k, sequence-space Jacobians $J^{A,C^*,k}$ and $J^{A,i^*,k}$ as well as $J^{Q,C^*,k}$ and $J^{Q,i^*,k}$ of asset demand A and the real exchange rate Q to the world aggregates C^*, i^*. We can then aggregate these Jacobians into a world Jacobian using, for instance, $J^{A,C^*} = \sum \omega^k J^{A,C^*,k}$. Second, we calculate the change in net asset supply $d\boldsymbol{B}^{k,0} - d\mathbf{A}^{k,0}$ and the real exchange rate $d\mathbf{Q}^{k,0}$ that results from the fiscal shock specific to country k. Finally, we differentiate the two equations, (31) and (32), through which countries interact. This gives us a simple linear system in $2T$ unknowns, where T is the truncation horizon of the sequence-space Jacobians:

$$
\begin{aligned}
J^{Q,C^*} d\boldsymbol{C}^* + J^{Q,i^*} d\boldsymbol{i}^* &= -\sum \frac{\omega^k}{1-\alpha^k} d\mathbf{Q}^{k,0} \\
J^{A,C^*} d\boldsymbol{C}^* + J^{A,i^*} d\boldsymbol{i}^* &= \sum_k \left(d\boldsymbol{B}^{k,0} - d\mathbf{A}^{k,0} \right)
\end{aligned}
$$

Inverting this system delivers the first-order solution for $(d\boldsymbol{C}^*, d\boldsymbol{i}^*)$. This type of procedure is helpful to solve models any time multiple groups of heterogeneous agents interact via a limited set of aggregates.

E.3 Covid shock matching procedure

Figure 21 illustrates the procedure we use to recover the Covid shock in each country. As discussed in the main text, we first use our model with only the fiscal shock to back out the counterfactual effect of the fiscal shock on consumption in each country. This delivers the red line. Then, assuming that, in each country, the Covid shock is an AR(1) discount factor shock, with country-specific magnitude σ^k and a common persistence ρ, we pick (σ^k, ρ) so that so that the combined effect of the fiscal and the Covid shock matches the data in the solid black line. The blue line visualizes the resulting effect of the Covid shock alone on consumption. The dashed black line visualizes the combined effect of the Covid shock and the fiscal shock, to compare to our target in the solid black line.

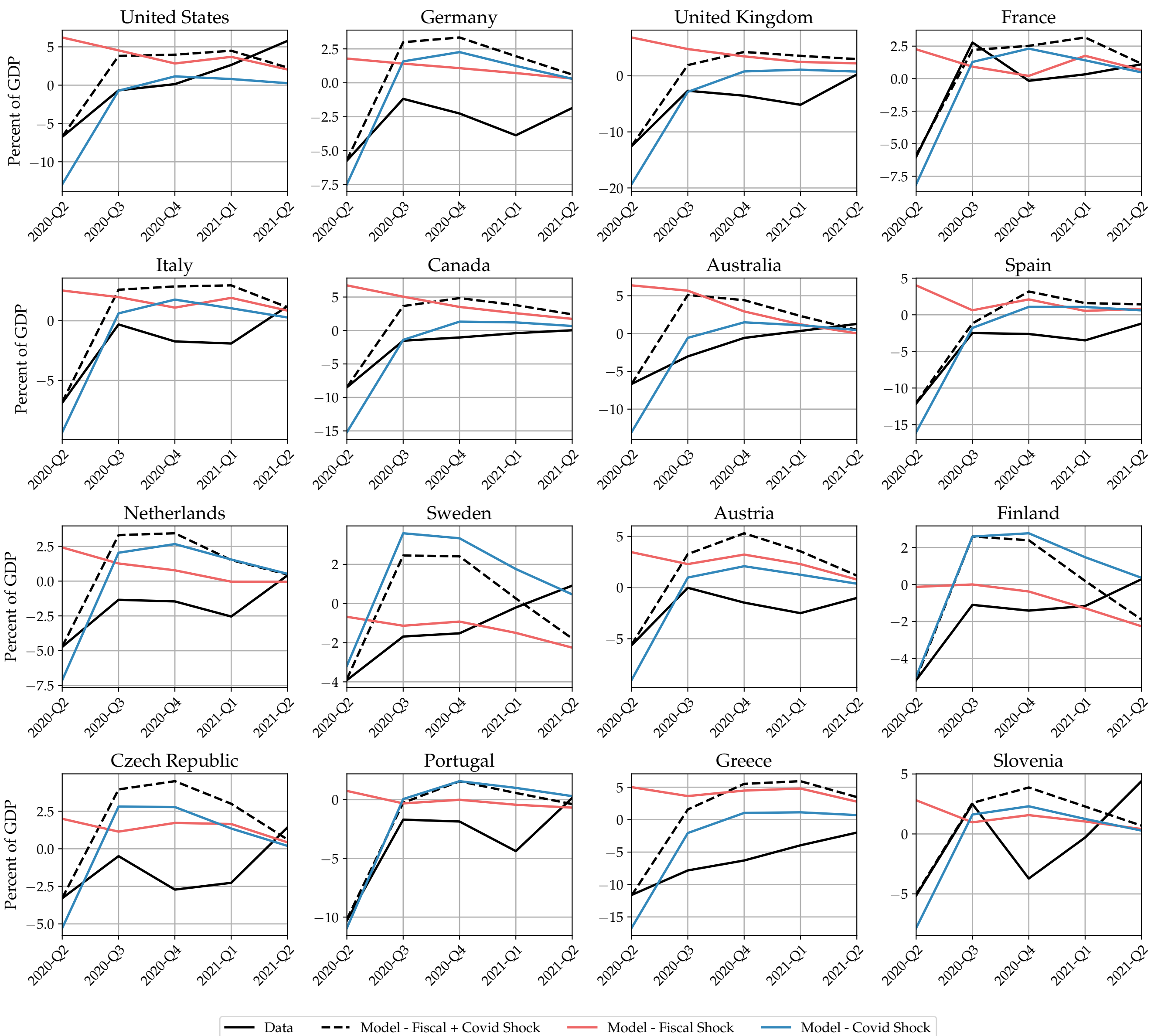


Figure 21: Recovering a Covid shock in each country